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REPORT FOR CONSULTATION OF THE METROPOLITAN TOLEDO INTERSTATE AIR QUALITY CONTROL REGION (OHIO-MICHIGAN)

National Air Pollution Control Administration
Washington, D. C.

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REPORT FOR CONSULTATION OF THE METROPOLITAN TOLEDO INTERSTATE AIR QUALITY CONTROL REGION (OHIO-MICHIGAN)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
National Air Pollution Control Administration

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PREFACE

The Air Quality Act of 1967 directs the Secretary of Health, Education, and Welfare to designate "air quality control regions" to provide a basis for the adoption of regional air quality standards and the implementation of those standards.

The Act stipulates that the designation of a region shall be preceded by consultation with appropriate State and local authorities. This report is intended to serve as background material for the consultation. It proposes boundaries for the Metropolitan Toledo Interstate Air Quality Control Region and discusses the factors which are the basis of the boundary proposal.

The Region* boundaries proposed in this report reflect consideration of available and pertinent information. However, the proposed boundaries remain subject to revisions suggested during consultation with State and local authorities. Formal designation of a Region will be made only after a careful review of all opinions and suggestions submitted during the consultation process.

The National Air Pollution Control Administration (NAPCA) appreciates assistance received from the State air pollution

*For the purpose of this report, the word "region", when capitalized, will refer to the Metropolitan Toledo Interstate Air Quality Control Region.

control programs of Ohio and Michigan, the Toledo Pollution Control Agency, the Toledo-Lucas County Planning Commissions, the Monroe County Planning Commission, and the Toledo Metropolitan Area Council of Governments.

INTRODUCTION

THE REGIONAL APPROACH

Air pollution in the urban areas of the United States is a regional problem which frequently extends across State and local governmental boundaries. Since air pollution problems are rarely confined to any single municipality or county, successful control requires coordinated planning, standard setting, and enforcement by the several political jurisdictions which share a common problem. At the present, State and local governments across the Nation have only begun to develop a regional approach to air pollution control.

The Clean Air Act as amended provides a regional approach which depends upon coordination and cooperation between all levels of government: municipal, county, State, and Federal. To set in motion the machinery for regional air pollution control, the Department of Health, Education, and Welfare first designates air quality control regions, issues air quality criteria, and publishes reports on control techniques. The region designation indicates which State and local jurisdictions will be involved in a regional air pollution control effort. The air quality criteria indicate the extent to which various concentrations of an air pollutant are harmful to health and damaging to property. The reports on control techniques provide information on the costs and effectiveness of various techniques for controlling air pollutant emissions.

After the Department of Health, Education, and Welfare completes these initial steps, State governments develop air quality standards and plans for implementation of those standards for portions of air quality control regions within their boundaries. An air quality standard defines the desired limit on the concentration of a pollutant in the ambient air of the region. It constitutes the degree of air quality which the regional control program will attempt to achieve. An implementation plan is a blueprint of the steps which will be taken to insure achievement of the air quality standards within a reasonable time. The Governors have 90 days to submit letters indicating that they intend to set standards, 180 days in addition to set the standards, and 180 days further to develop plans for implementing them. The procedure for setting standards includes a public hearing which allows residents of a region to express their views concerning desired standards.

The Department of Health, Education, and Welfare reviews air quality standards and implementation plans in order to ascertain their consistency with the provisions of the Clean Air Act as amended.

When air quality standards and implementation plans are approved, States proceed to prevent and control air pollution in accordance with those standards and plans. This system for establishing a regional approach to air pollution control is depicted in the flow diagram in Figure 1.

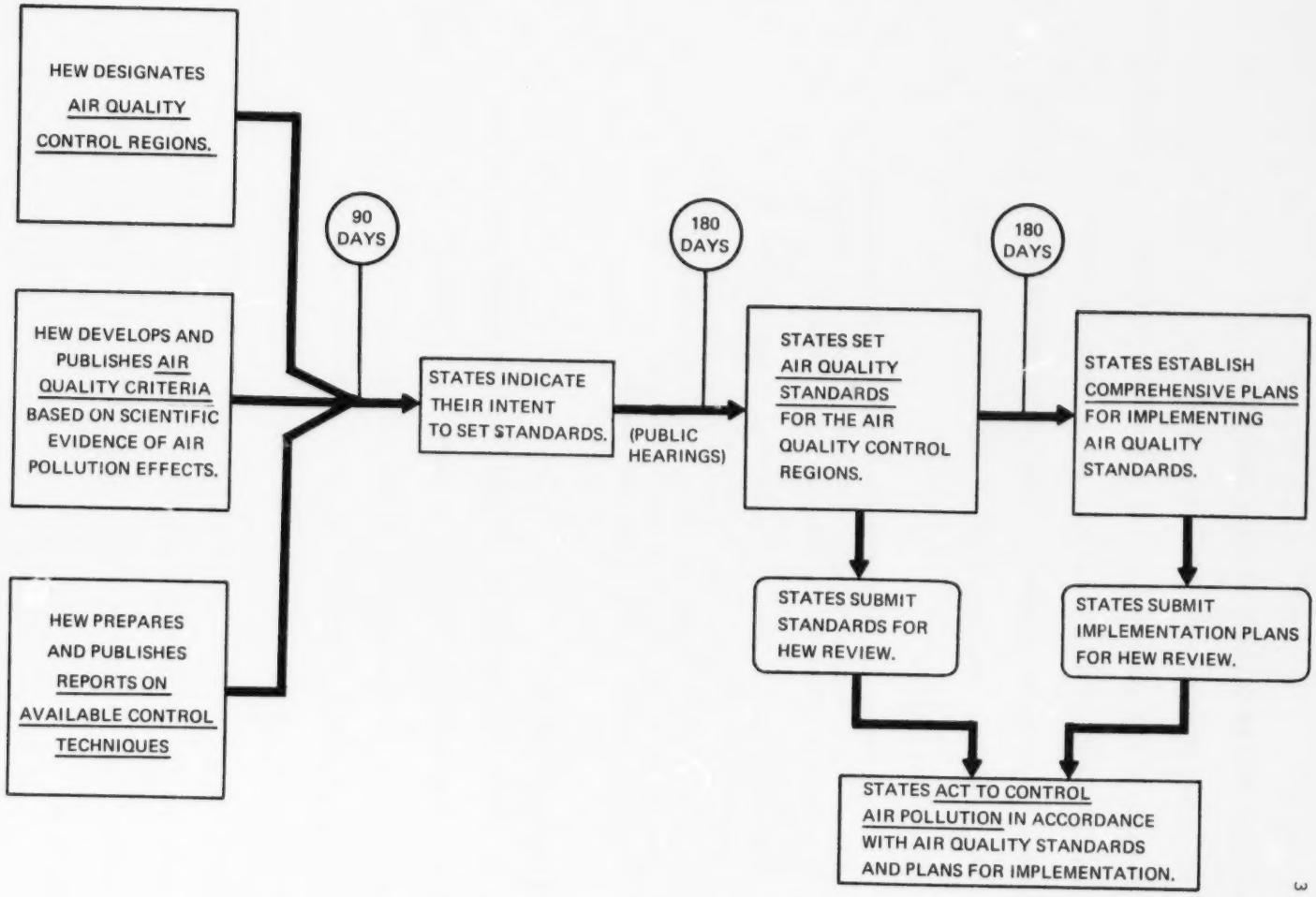
HEW DESIGNATES AIR QUALITY CONTROL REGIONS.
HEW DEVELOPS AND PUBLISHES AIR QUALITY CRITERIA BASED ON SCIENTIFIC EVIDENCE OF AIR POLLUTION EFFECTS.
HEW PREPARES AND PUBLISHES REPORTS ON AVAILABLE CONTROL TECHNIQUES
90 DAYS
STATES INDICATE THEIR INTENT TO SET STANDARDS.
180 DAYS
(PUBLIC HEARINGS)
STATES SET AIR QUALITY STANDARDS FOR THE AIR QUALITY CONTROL REGIONS.
180 DAYS
STATES ESTABLISH COMPREHENSIVE PLANS FOR IMPLEMENTING AIR QUALITY STANDARDS.
STATES SUBMIT STANDARDS FOR HEW REVIEW.
STATES SUBMIT IMPLEMENTATION PLANS FOR HEW REVIEW.
STATES ACT TO CONTROL AIR POLLUTION IN ACCORDANCE WITH AIR QUALITY STANDARDS AND PLANS FOR IMPLEMENTATION.

Figure 1. FLOW DIAGRAM FOR ACTION TO CONTROL AIR POLLUTION ON A REGIONAL BASIS, UNDER THE AIR QUALITY ACT.

DESIGNATION OF AIR QUALITY CONTROL REGIONS

Designation of an air quality control region is one of the first steps in the regional approach to air pollution control. Section 107(a)(2) of the Clean Air Act as amended directs the Secretary, Department of Health, Education, and Welfare to make such designations. The portions of the section relevant to this discussion state:[1]

> "...The Secretary, after consultation with appropriate State and local authorities shall...designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards. The Secretary may...revise the designation of such regions...The Secretary shall immediately notify the Governor or Governors of the affected State or States of such designation."

The Size of a Region

As stipulated in Section 107(a)(2), the designation of air quality control regions should be based on "jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards." This language suggests a number of objectives which are important in determining how large an air quality control region should be. Basically, these objectives can be divided into three separate categories.

---

[1]For the complete text of Section 107(a)(2), see Appendix A.

First, a region should be self-contained with respect to air pollution sources and receptors. In other words, a region should include most of the important sources in the area as well as most of the people and property affected by those sources. In this way, all the major elements of the regional problem will lie within one unified administrative jurisdiction. Unfortunately, since air pollutants can travel long distances, it is impractical if not impossible to delineate regions which are completely self-contained. The air over a region will usually have at least trace amounts of pollutants from external sources. During episodic conditions, such contributions from external sources may even reach significant levels. Conversely, air pollution generated within a region and transported out of it can affect external receptors to some degree. It would be impractical and inefficient to make all air quality control regions large enough to encompass these low-level trace effects. The geographic extent of trace effects overestimates the true problem area which should be the focus of air pollution control efforts. Thus, the first objective, that a region be self-contained, becomes a question of relative magnitude and frequency. The dividing line between "important influence" and "trace effect" will be a matter of judgment. The judgment should be based on estimates of the impact a source has upon a region and the level of pollution to which receptors are subjected. In this respect, annual and seasonal data on pollutant emissions and ambient air concentrations are a better measure of relative influence than short term data on episodic conditions.

The second general objective requires that region boundaries be designed to meet not only present conditions but also future conditions. In other words, the region should include areas where industrial and residential expansion are likely to create air pollution problems in the foreseeable future. This objective requires careful consideration of existing metropolitan development plans, expected population growth, and projected industrial expansion. Such considerations should result in the designation of regions which will contain the sources and receptors of regional air pollution for a number of years to come. Of course, region boundaries need not be permanently fixed, once designated. Boundaries should be reviewed periodically and altered when changing conditions warrant readjustment.

The third objective is that region boundaries should be compatible with and even foster unified and cooperative governmental administration of the air resource throughout the region. Air pollution is a regional problem which often extends across several municipal, county, and even State boundaries. Clearly, the collaboration of several governmental jurisdictions is prerequisite to the solution of the problem. Therefore, the region should be delineated in a way which encourages regional cooperation among the various governmental bodies involved in air pollution control. In this regard, the existing pattern of governmental cooperation on the whole range of urban problems may become an important consideration. Certainly the pattern

of cooperation among existing air pollution control programs is a relevant factor. In general, administrative considerations dictate that governmental jurisdictions should not be divided. Although it would be impractical to preserve State jurisdictions undivided, usually it is possible to preserve the unity of county governments by including or excluding them in their entirety. Occasionally, even this would be impractical due to a county's large size, wide variation in level of development, or striking topographical features.

To the extent that any two of the above three objectives lead to incompatible conclusions concerning region boundaries, the region must represent a reasonable compromise. A region should represent the best way of satisfying the three objectives simultaneously.

Procedure for Designation of Regions

Figure 2 illustrates the procedures used by the National Air Pollution Control Administration for designating air quality control regions.

After evaluating relevant engineering factors and urban factors, the National Air Pollution Control Administration publishes a proposed delineation of the region boundaries. At the same time NAPCA sets a time and place for a consultation meeting and distributes to State and local authorities a report of the evaluation study which includes the boundary proposal.

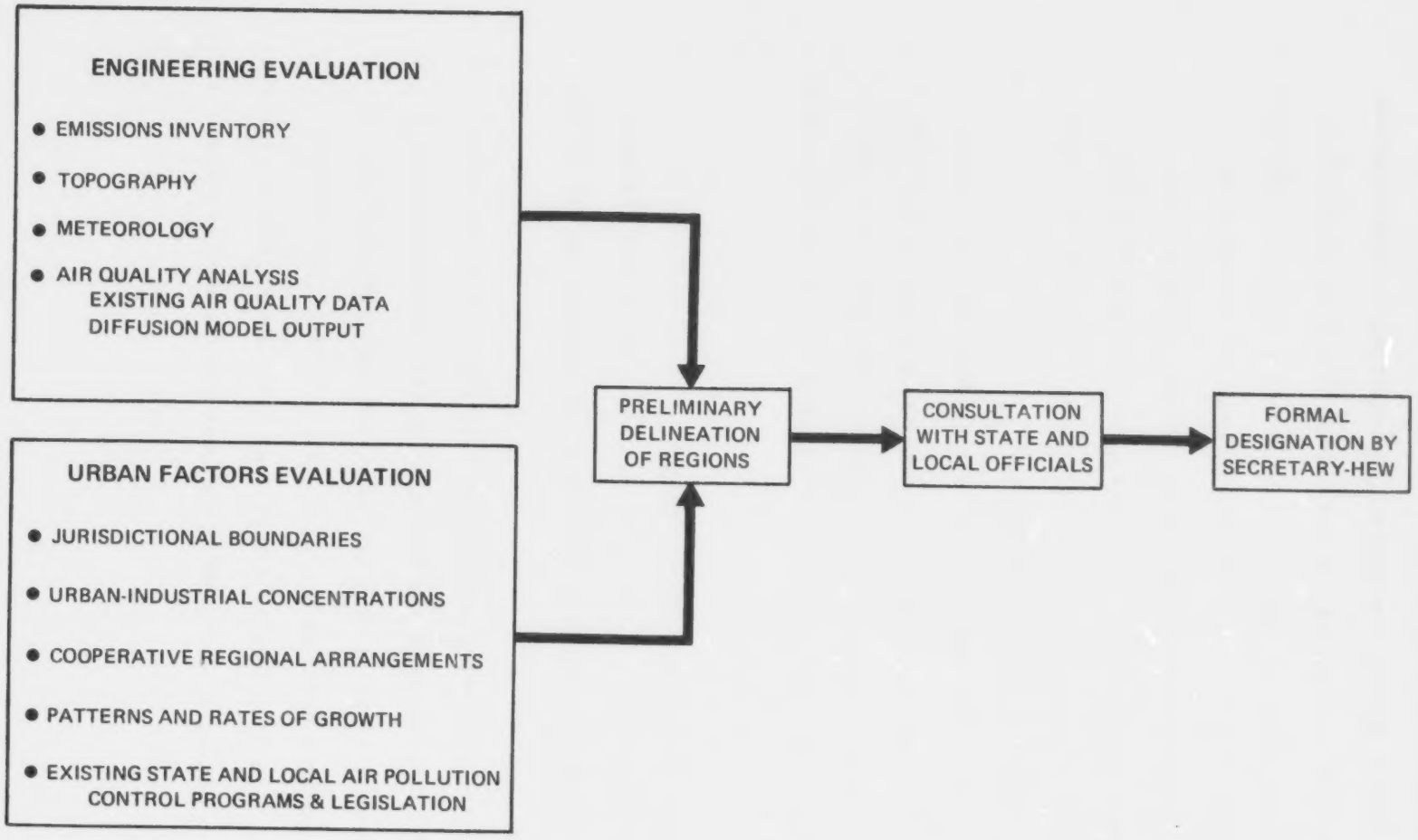
ENGINEERING EVALUATION
• EMISSIONS INVENTORY
• TOPOGRAPHY
• METEOROLOGY
• AIR QUALITY ANALYSIS
EXISTING AIR QUALITY DATA
DIFFUSION MODEL OUTPUT
URBAN FACTORS EVALUATION
• JURISDICTIONAL BOUNDARIES
• URBAN-INDUSTRIAL CONCENTRATIONS
• COOPERATIVE REGIONAL ARRANGEMENTS
• PATTERNS AND RATES OF GROWTH
• EXISTING STATE AND LOCAL AIR POLLUTION CONTROL PROGRAMS & LEGISLATION
PRELIMINARY DELINEATION OF REGIONS
CONSULTATION WITH STATE AND LOCAL OFFICIALS
FORMAL DESIGNATION BY SECRETARY-HEW

Figure 2. FLOW DIAGRAM FOR THE DESIGNATION OF AIR QUALITY CONTROL REGIONS.

At the consultation meeting State and local authorities are encouraged to present fully their views and suggestions concerning the proposed boundaries of the region. Interested parties who do not have official status may submit comments in written form for the record. After careful review of all suggestions and opinions submitted for the record by interested parties, the Secretary of Health, Education, and Welfare makes a formal designation of the region boundaries and notifies the Governors of the designation.

As noted above, the evaluation of relevant engineering factors and urban factors forms the basis of the boundary proposals published by NAPCA. The evaluation of engineering factors is designed to indicate the location of pollution sources and the geographic extent of serious pollutant concentrations in the ambient air. Pollution sources are located by taking an inventory of emissions from automobiles, industrial activities, space heating, waste disposal, and other pollution generators. The transport and distribution of pollutants in the ambient air are analyzed on the basis of measured air quality data, the location of emissions, meteorological data, and topographic information. A mathematical diffusion model which predicts ambient pollution concentrations from information on emissions and meteorology can be used in areas where irregular topographical features would not invalidate the theoretical model. As a whole, the engineering study indicates how large the air quality control region must be in order to encompass most pollution sources and most people and property affected by those sources.

The study of urban factors encompasses non-engineering considerations. It reviews existing governmental jurisdictions, the location of urban and industrial concentrations, expected patterns of urban growth, cooperative regional arrangements, existing State and local air pollution control programs, and other associated factors. As a whole, the study of urban factors is designed to indicate how large a region must be in order to encompass expected regional growth and to encourage cooperation among political units in controlling air pollution.

The body of this report contains a proposal for the boundaries of the Metropolitan Toledo Interstate Air Quality Control Region and outlines the evaluation of engineering and urban factors which was the basis of the proposal. The report is intended to serve as the background document for the consultation with appropriate State and local authorities.

EVALUATION OF URBAN FACTORS

INTRODUCTION

A number of urban factors are relevant to the problem of defining air quality control region boundaries. First, the location of population is an important consideration, since human activity is the prime cause of air pollution, and humans are the ultimate victims. The population growth pattern is another important consideration, since an air quality control region should be designed not only for the present but also for the future. The location of industrial activity and the industrial growth pattern are relevant considerations for similar reasons. Political and jurisdictional considerations are also important, since the Clean Air Act, as amended, envisions regional air pollution programs based on cooperative efforts among many political jurisdictions. The following discussion of urban factors will present these considerations as they apply to the Toledo metropolitan area.

Regional Setting

The three counties of Lucas, Monroe, and Wood comprise the Toledo Standard Metropolitan Statistical Area (SMSA).* Ottawa

*SMSA's are defined by the Bureau of the Census and other Federal agencies for use in publishing census data and a variety of other government statistics. An SMSA is composed of one county or a group of contiguous counties which contains at least one central city of 50,000 inhabitants or more or twin-cities with a combined population of at least 50,000. In addition, other contiguous counties are included in an SMSA if, according to certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city.

and Sandusky Counties are not presently part of an SMSA. Putnam County is in the Lima SMSA. Figure 3 outlines the Toledo SMSA and shows parts of four other SMSA's.

Four air quality control regions have been designated in the State of Ohio--Cleveland (intrastate), Cincinnati (tri-state), Dayton (intrastate), and Steubenville-Weirton-Wheeling (bi-state). In Michigan, a four-county intrastate air quality control region for the Detroit area has been proposed by NAPCA.* The proposed Detroit-Port Huron region includes Macomb, Oakland, St. Clair, and Wayne Counties.

POPULATION

Figure 4 and Table 1 show present population density by county in the Toledo area.[1,2,3] Highest densities are exhibited by Lucas County (Toledo) and Wayne County (Detroit). In Ohio, the counties south and southeast of Lucas show higher densities than those counties west of Lucas County. Monroe County, Michigan, located between Lucas and Wayne Counties, has a population density of about 210 residents per square mile which is higher than the densities of the remaining counties contiguous to Lucas County.

Toledo is the fourth largest city in Ohio. With an estimated 1969 population of 385,000 (80% of Lucas County), it is the center of a trading area which includes seven northwest Ohio counties.**[3] Figure 5 shows Toledo's urban area in Lucas County.

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*At the date of publication of this report, the Secretary of Health, Education, and Welfare had not formally designated the boundaries of the Detroit AQCR.

**Williams, Fulton, Defiance, Henry, Wood, Ottawa, and Lucas.

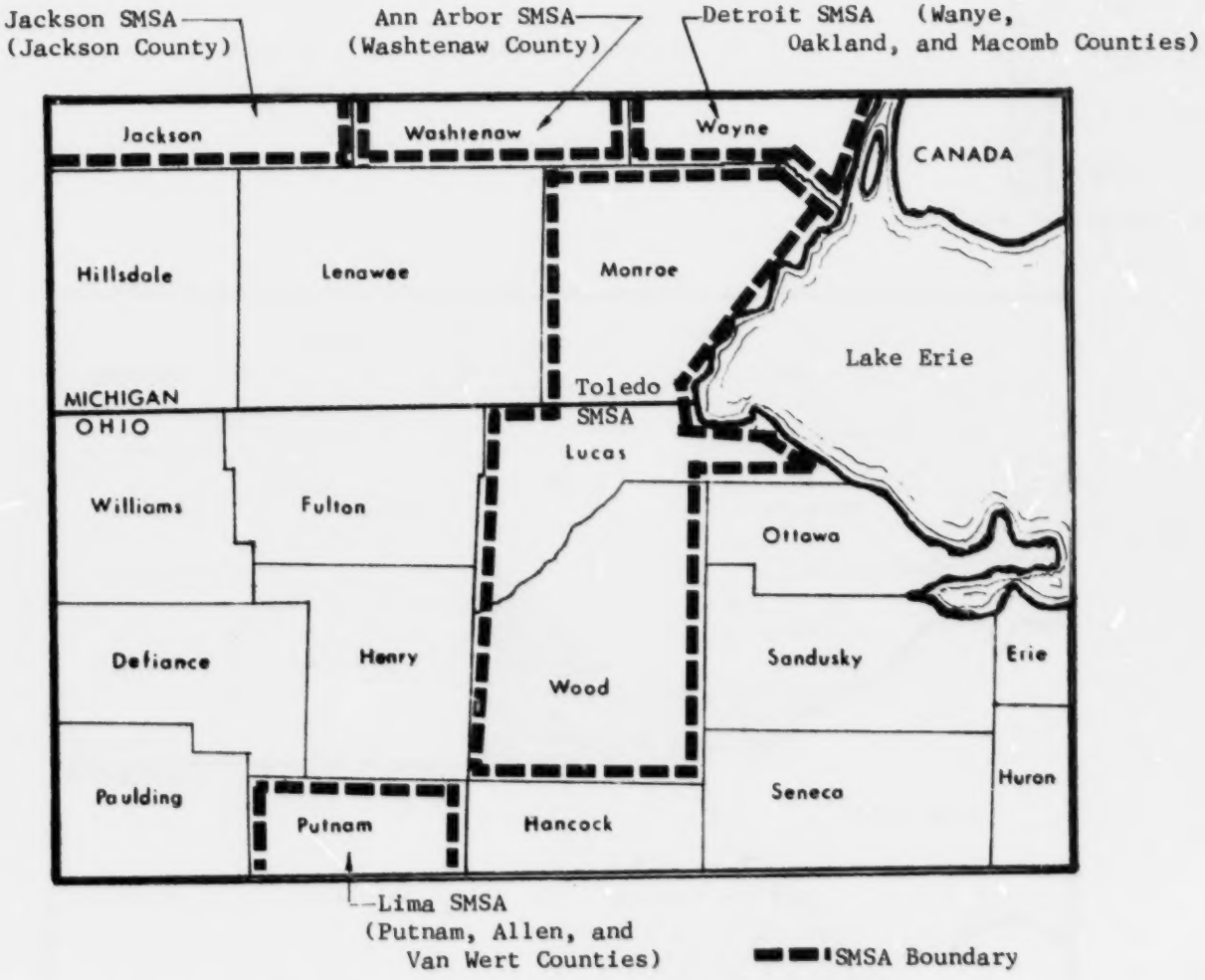


Figure 3. Map of Standard Metropolitan Statistical Areas (SMSA's).

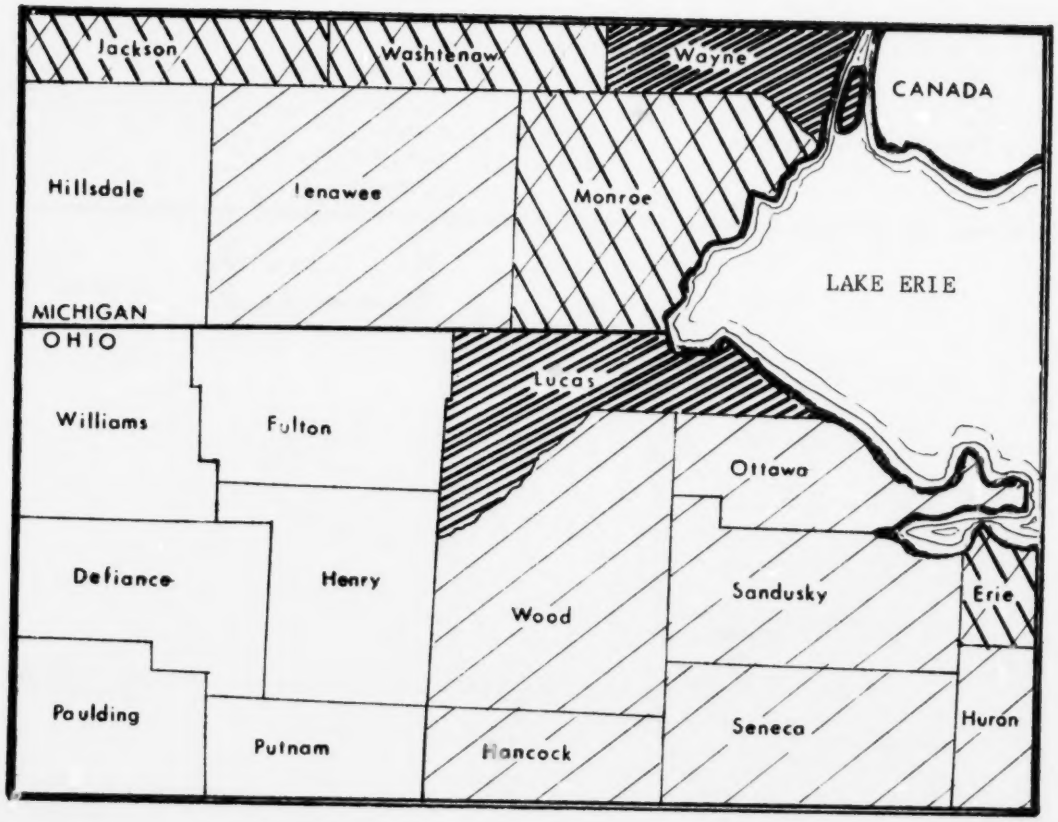


Figure 4. 1969 Population Density

TABLE I. TOLEDO POPULATION AND EMPLOYMENT DATA

	County	BTA/MTA* [3]	Area mi.^{2}	Population 1969 [3]	Pop. Den. 1969 res./mi.^{2}	Population 1980 [1,2]	Pop. Den. 1980 res./mi.^{2}	Add. Res. per mi.^{2} 1969-'80	% increase or decrease 1969-'80	Manufacturing Employees 1963 [3]	Manuf. Employ. Density, 1963 Employ./mi.^{2}
OHIO	Defiance	Tol/Det	412	35,300	86	40,900	98	12	14	4,647	11
	Erie	Sand/Clev	264	77,500	294	98,100	371	77	26	9,681	37
	Fulton	Tol/Det	407	30,900	76	37,800	93	17	22	3,102	8
	Hancock	Find/Det	532	66,500	125	75,600	142	17	14	6,483	12
	Henry	Tol/Det	416	26,000	63	31,000	75	12	19	2,970	7
	Huron	Sand/Clev	497	52,300	106	60,500	122	16	15	4,800	10
	Lucas	Tol/Det	343	480,000	1400	542,500	1580	180	13	57,785	168
	Ottawa	Tol/Det	261	34,300	131	45,800	176	45	34	3,179	12
	Paulding	FtW,I/Chi	418	20,100	48	20,100	48	0	0	909	2
	Putnam	Find/Det	486	32,800	67	34,100	70	3	4	2,467	5
	Sandusky	Fre/Det	409	58,800	144	75,200	185	41	29	6,103	15
	Seneca	Fre/Det	551	60,600	110	72,900	132	22	20	8,055	14
	Williams	Tol/Det	421	32,000	76	36,200	86	10	13	5,122	12
	Wood	Tol/Det	619	82,000	133	96,900	157	24	18	6,122	10
MICHIGAN	Hillsdale	Jack/Det	600	34,700	58	35,130	59	1	2	2,468	4
	Jackson	Jack/Det	698	140,000	201	144,145	206	5	2	16,501	24
	Lenawee	Adr/Det	753	80,600	107	81,510	108	1	1	10,201	14
	Monroe	Det/Det	557	117,000	210	132,823	230	20	10	6,837	12
	Washtenaw	Det/Det	711	233,000	328	300,382	426	98	30	25,827	36
	Wayne	Det/Det	605	2,740,000	4540	2,700,501**	4470	-70**	-2	357,663	592

*Basic Trading Area/Major Trading Area [3]

**The "Population Study" by TALUS (Detroit Regional Transportation and Land Use Study), 1967, gives a projected 1980 population for Wayne County as approximately 2,900,000 or an increase of 260 residents per square mile.

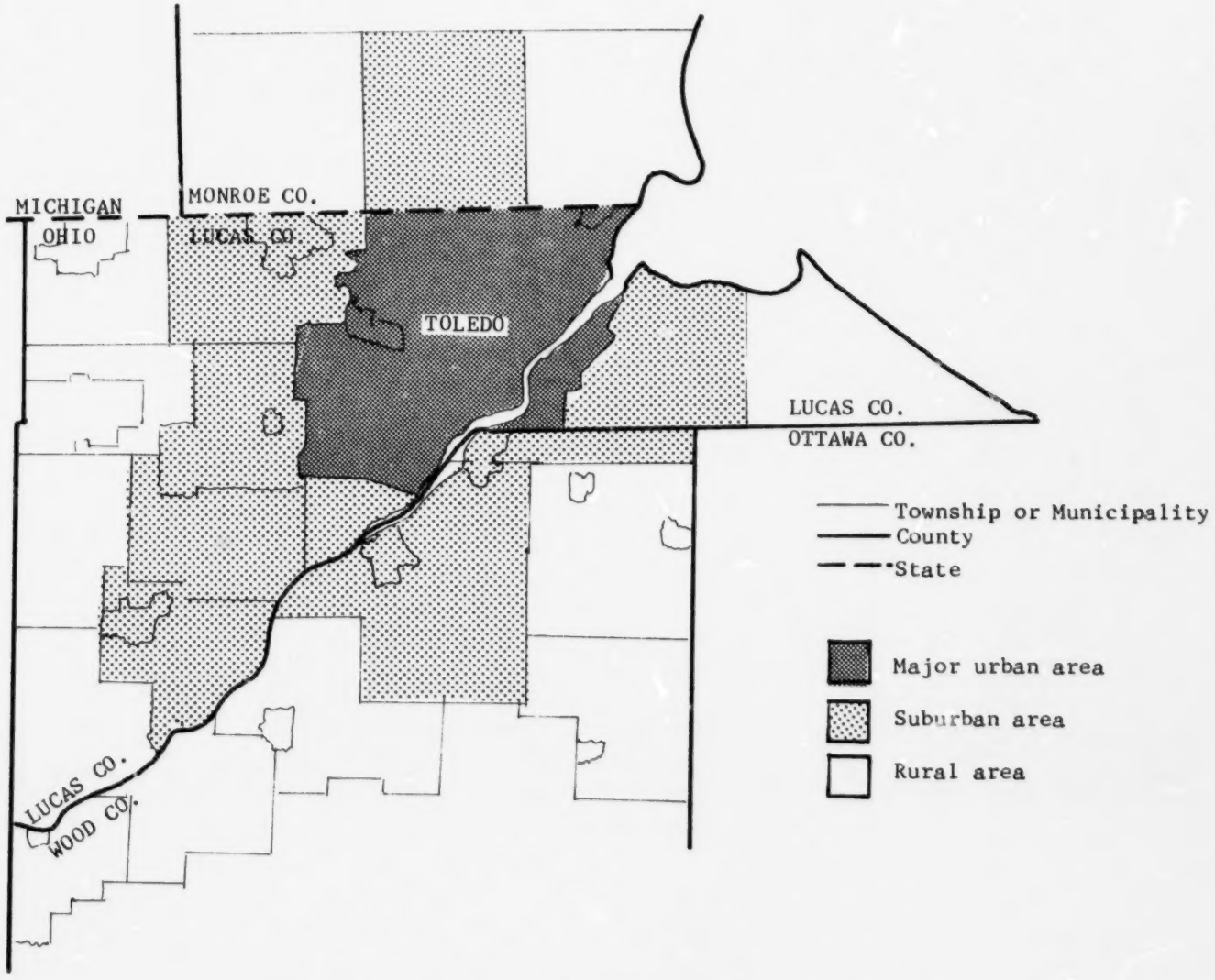


Figure 5. General Population Areas[4]

The suburban areas spill north into Monroe County and south into Wood County.

Projected population figures by county are given in Table I and illustrated in Figure 6.[1,2,3] Highest absolute growth in the next decade in terms of additional residents per square mile is expected to occur in Lucas County. Though population in Toledo is fairly stable, growth of the suburbs will be dynamic. The urban population in 1965 accounted for 72% of the Toledo Regional Area* and the suburban for 21%; in 1985, it is expected that the proportions will be 62% and 29%, respectively. In general, the majority of population growth, based on growth trends, is expected to be to the north and south of the City of Toledo[4] which would include areas in southern Monroe County and northern Wood County. Ottawa and Sandusky Counties, however, are projected to increase by over 40 additional residents per square mile by 1980, which represents a percentage rate of growth of 34% and 29%, respectively. Thus, on the basis of county projections, Sandusky and Ottawa are projected for greater population growth in the next decade than Monroe and Wood Counties.

INDUSTRY

Two methods are employed to show the location of industry in the Toledo area. Figure 7 illustrates the density of manufacturing employment based on 1963 figures.[3] Wayne and Lucas

*Lucas County plus parts of Monroe and Wood Counties.

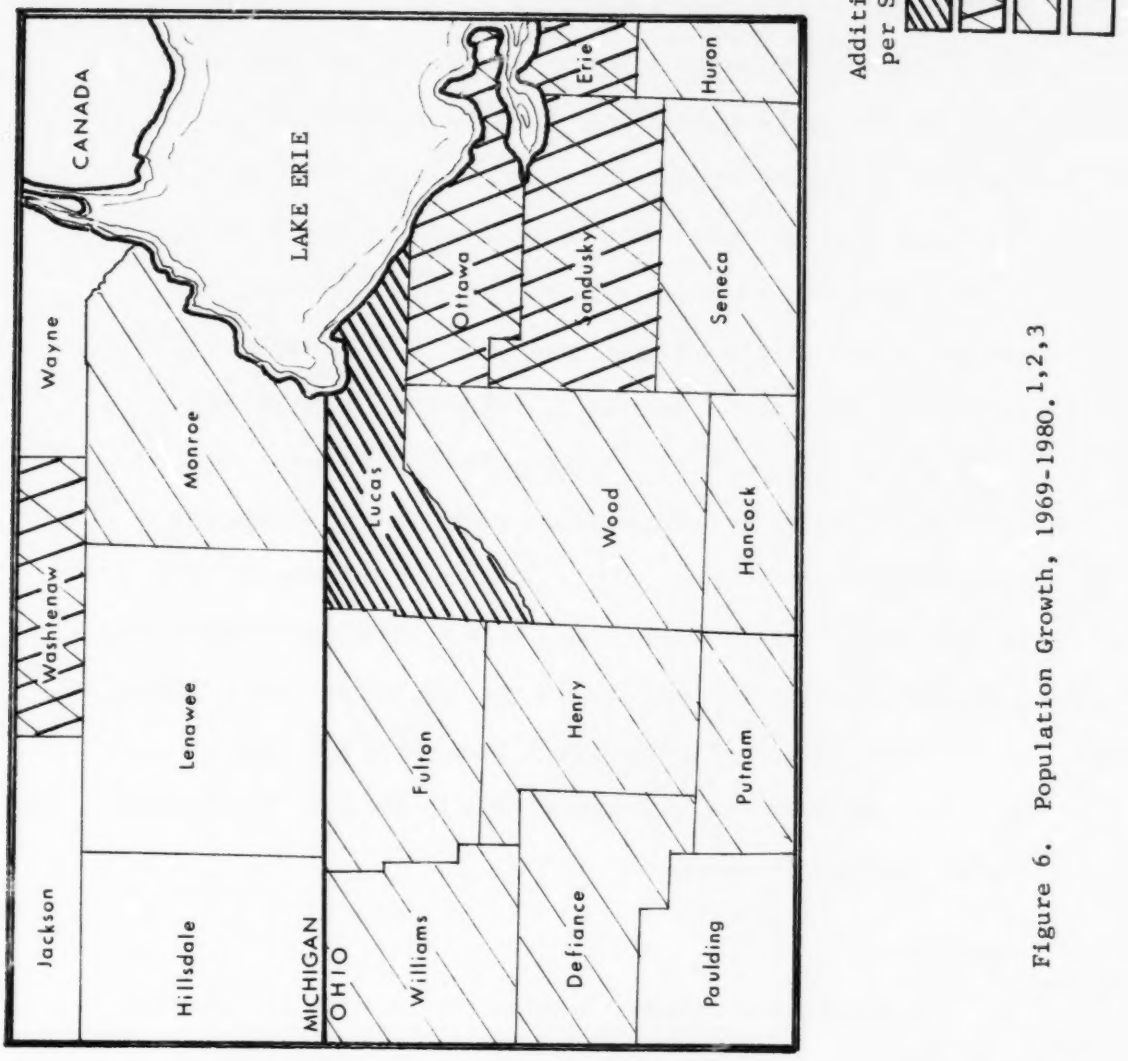


Figure 6. Population Growth, 1969-1980.[1,2,3]

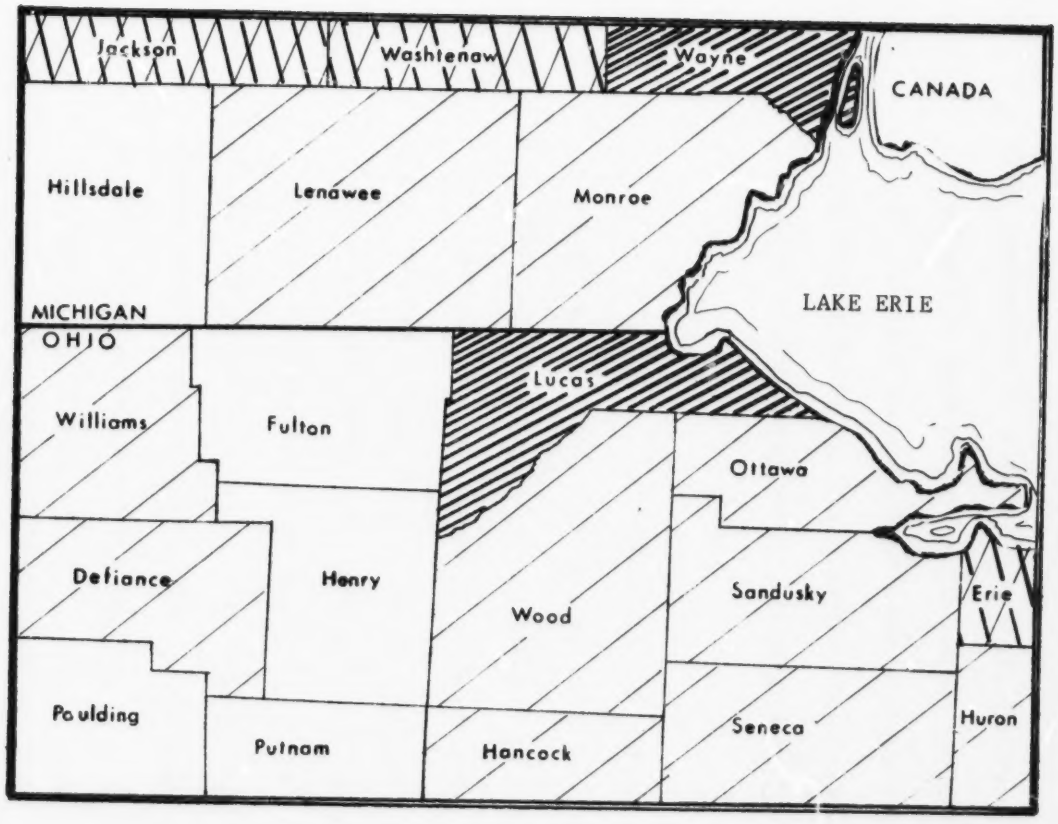


Figure 7. Manufacturing Employment Density, 1963.[3]

Counties have the highest densities with 592 and 168 manufacturing employees per square mile, respectively. Outside of these counties, the density is quite low. Within the Toledo Study Area, the counties of Monroe, Wood, Ottawa, and Sandusky have between 10 and 20 employees per square mile.

Figure 15 (page 36) gives the location of industries which are major contributors to the air pollution load in the five counties of Lucas, Wood, Ottawa, Sandusky, and Monroe. The heaviest concentration of industry is found along the Maumee River in Lucas and Wood Counties, in northeast Toledo, and in Monroe City.

EXISTING AIR POLLUTION CONTROL PROGRAMS

In the State of Ohio, responsibility for air pollution control rests upon an Air Pollution Control Board located within the State Department of Health. In order to meet its responsibility, the Board is authorized to prescribe ambient air quality standards for various sections of the State, to enforce emission standards designed to meet the air quality standards in those sections, and to issue variance permits for exceptional circumstances. Under existing law in Ohio, county governments can develop air pollution control programs only as part of their health program. County regulations concerning air pollution control do not apply within municipal boundaries if the city or incorporated area has its own regulations. Due to this limitation on county jurisdiction, municipal government has become the most usual unit in Ohio for administration of local air pollution control programs.

The Pollution Control Agency of the City of Toledo handles air pollution control in the city of Toledo and in the suburban communities of Oregon (Lucas County) and Rossford (Wood County). The Pollution Control Director reports directly to the Toledo City Manager. Providing the legal authority for the Agency is the Air Pollution Code of Toledo. This Code is presently being revised to contain more stringent provisions. The Toledo program has an extensive sampling network to monitor particulates, SO_2, CO, NO-NO_2, and oxidants. An emission inventory conducted by a private consulting firm will be kept current by the Agency in years to come.

The Air Pollution Control Section of the Michigan Department of Public Health administers a comprehensive air pollution control program on a state-wide basis. Local units of government may administer their own air pollution control program if the rules and regulations of the State are suspended by the State's Air Pollution Control Commission. The Michigan Air Pollution Control Commission may suspend its rules and regulations in a local jurisdiction which enacts regulations at least as stringent as those of the State. One aspect of the State program is its monitoring of air quality in the major metropolitan areas. Additional activities include the development of a comprehensive state-wide emission inventory and a schedule for emission control, and technical support to local community programs.

REGIONAL AGENCIES IN THE TOLEDO AREA

The Toledo Metropolitan Area Council of Governments (TMACOG) is the recognized area-wide planning and review agency in the Toledo area. TMACOG represents 65 local governments including counties (Lucas, Wood, and Monroe), cities, townships, and school districts. The three townships of Whiteford, Bedford, and Erie, and the city of Luna Pier in Monroe County are members of the TMACOG. Activities of the TMACOG include law enforcement planning and land-use planning (water, sewage, open-space). The TMACOG recently completed a regional solid-waste management system study and are involved in mass-transit studies.

Monroe County and the City of Luna Pier are also members of the SEMCOG--Southeast Michigan Council of Governments--which also includes Macomb, Oakland, St. Clair, Washtenaw, and Wayne Counties. The Planning Division of SEMCOG handles regional planning activities in the above six counties plus Livingston County. Regional planning in Monroe County is the responsibility of SEMCOG except in the southern three townships of Whiteford, Bedford, and Erie, which are under TMACOG. Besides the Planning Division, SEMCOG has divisions of public works, public safety, health, education, and governmental services.

The Toledo-Lucas County Plan Commissions consist of two separate bodies--the Toledo City Plan Commission and the Lucas County Plan Commission. The Commissions have been meeting together

since 1932 to promote program coordination. The planning staff of the Commissions provides zoning, platting and related services. In addition, preparation of the "Toledo Regional Area Plan for Action" has been assigned to the staff of the Commissions. The Regional Plan will cover comprehensive land-use and transportation planning in the Toledo Regional Area (Lucas County, three townships in Monroe County, and seven townships in Wood County).

In addition to the regional planning agencies and councils of government, county-wide planning commissions exist in Wood, Sandusky, Ottawa, and Monroe Counties. The Monroe County Planning Commission prepared "COMPLAN: 2000, Comprehensive Development Plan for Monroe County Region, 1967-2000." COMPLAN contains proposals and recommendations for future development of the county.

EVALUATION OF ENGINEERING FACTORS

INTRODUCTION

The engineering evaluation for the Toledo area was based on a study of topography, meteorology, air pollutant emissions, estimated air quality levels, and available ambient air quality data. The emission inventory indicated the location of point and area sources and quantity of pollutants emitted from these sources. Emission densities were calculated from the emission quantities and grid zone areas. Emissions and average meteorological data were used in a diffusion model[5] to estimate air quality levels in the Toledo Study Area.*

TOPOGRAPHY AND METEOROLOGY

The Toledo Study Area is relatively flat. Elevations range from 570 feet (Lake Erie) to 720 feet in northwest Monroe County. Toledo stands along both banks of the Maumee River, near the point where the river widens to form Maumee Bay at the western end of Lake Erie. The valley formed by the Maumee River is an axis for the topography. The slopes of the valley are very gentle, ranging from 3-7 feet per mile, except for the river bank of about 30 feet. There is a low range of hills in northwest Monroe County.

Lake Erie has a moderating effect on the weather in the Study Area. Extremes in temperature are seldom recorded. Predominant winds are from the WSW-SSW in Lucas County, and from

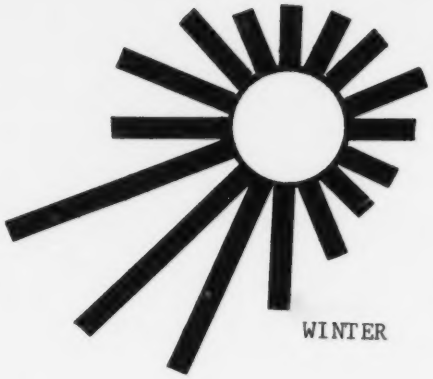
* The Toledo Study Area refers to the Counties of Lucas, Ottawa, Sandusky, and Wood, in Ohio, and Monroe County, Michigan.

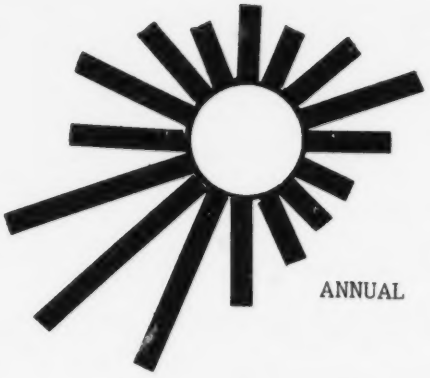
the west and southwest in Monroe County. Wind roses, drawn from data measured at the Toledo Municipal Airport, are shown in Figure 8. Average mixing depths, the depth of the air layer in which pollutants may mix and be dispersed, are shown in Figure 8. The potential for vertical dispersion is highest during summer afternoons, but dispersion is restricted during the mornings throughout the year. In general, the topography and meteorology in the Toledo area tend to relieve rather than aggravate the air pollution problem.

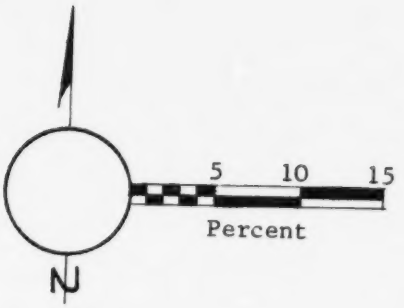
EMISSIONS INVENTORY

The National Air Pollution Control Administration conducted an inventory of air pollutant emissions for the Toledo Study Area. Five pollutants were inventoried--total particulates, sulfur oxides, carbon monoxide, nitrogen oxides, and hydrocarbons. Only three of these--total particulates, SO_X, and CO--are considered in this report, since these pollutants provide an indication of the general air pollution problem. Particulate emission levels indicate primarily the location and extent of pollution emanating from industrial, power, incineration, and heating sources. Levels of sulfur oxides illustrate the impact of fuel burning activities at stationary sources. Levels of carbon monoxide show the impact of gasoline-powered motor vehicles on the regional air pollution pattern. A summary of the emissions inventory by jurisdiction and source category is given in Table II.

Figure 9 breaks down the total emissions into percent contribution by the various source categories. Steam-electric







Percent frequency of wind direction for various averaging times based on data from the Toledo Municipal Airport.

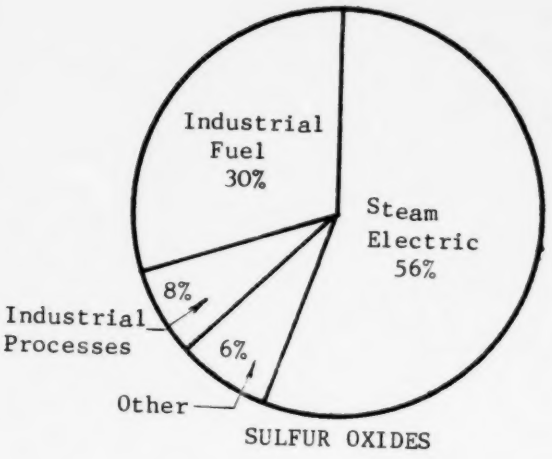
Average Mixing Depths for the Toledo Area
By Season in Meters

	Winter	Spring	Summer	Autumn	Annual
Morning	505	410	315	415	411
After-noon	750	1400	1590	1200	1235

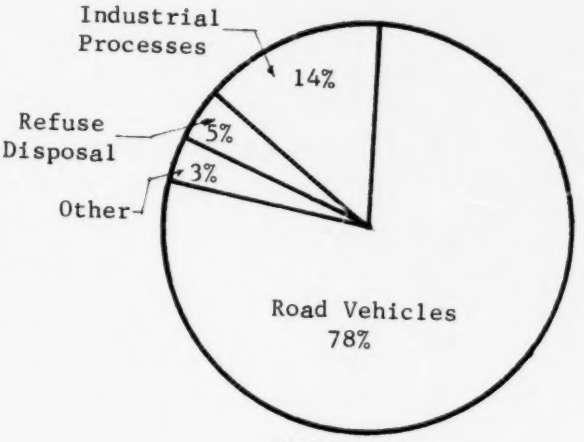
Figure 8. Meteorological Data for the Toledo Area.
(Wind Roses and Mixing Depths)

TABLE II. SUMMARY OF EMISSIONS FROM THE STUDY AREA BY SOURCE CATEGORY
(Tons per Year)

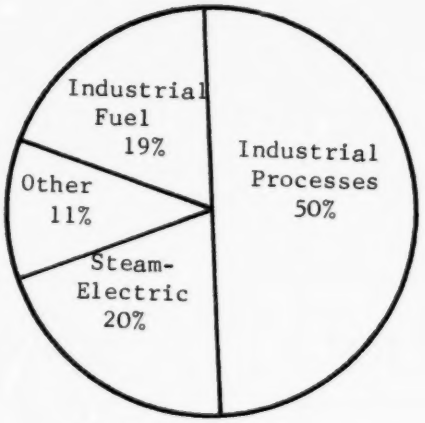
		FUEL COMBUSTION								
	County	Industrial	Institutional	Residential	Power Plants	Total Fuel	Industrial Process Losses	Transportation	Refuse Disposal	Total
Particulates	Lucas	5,600	300	300	2,400	8,600	26,400	1,500	1,300	37,800
	Ottawa	100	100	150	--	350	--	100	300	750
	Sandusky	100	200	200	--	500	--	200	500	1,200
	Wood	150	150	200	--	500	--	200	650	1,350
	Monroe	8,800	500	1,600	13,600	24,500	13,000	200	150	37,850
Sulfur Oxides	Lucas	43,900	500	500	69,700	114,600	16,900	1,300	100	132,900
	Ottawa	550	250	600	--	1,400	--	50	--	1,450
	Sandusky	1,000	450	900	--	2,350	--	100	--	2,450
	Wood	800	350	800	--	1,950	--	100	--	2,050
	Monroe	18,100	1,150	7,600	53,700	80,550	--	150	--	80,700
Carbon Monoxide	Lucas	500	200	200	400	1,300	42,900	156,000	6,600	206,800
	Ottawa	Neg.	100	250	--	350	--	10,900	1,700	12,950
	Sandusky	Neg.	200	400	--	600	--	21,900	2,550	25,050
	Wood	Neg.	150	300	--	450	--	21,900	3,350	25,700
	Monroe	500	500	3,100	200	4,300	--	26,700	850	31,850



SULFUR OXIDES



CARBON MONOXIDE



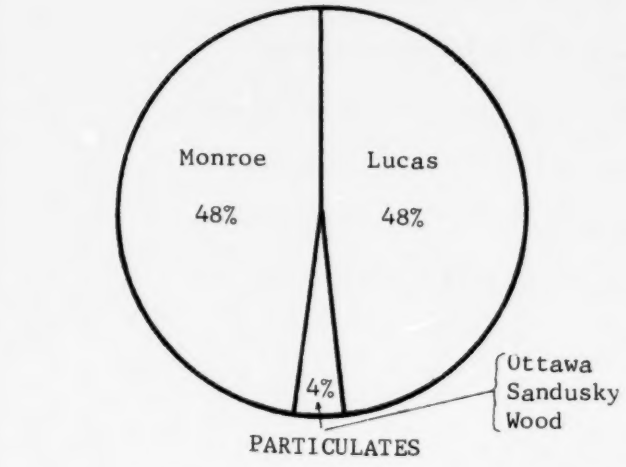
PARTICULATES

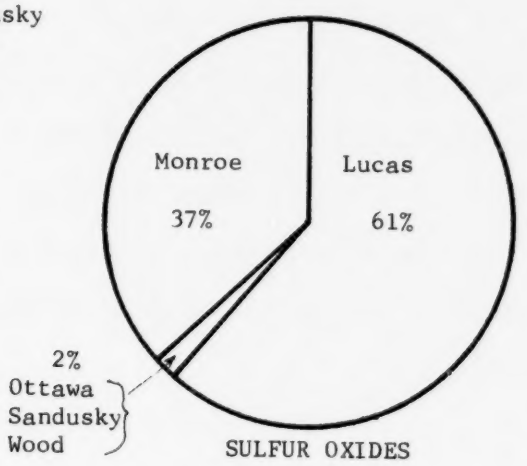
Figure 9. Emissions of Sulfur Oxides, Particulates, and Carbon Monoxide in the Study Area by various Source Categories.

power plants emit the majority of sulfur oxides pollution (56%), and industrial fuel usage contributes 30% of the total. Total particulate emissions are more evenly distributed by source category; industrial process sources contribute 50%, power plants, 20%, and industrial fuel usage, 19%, of the total. Transportation sources contribute the overwhelming majority of carbon monoxide pollution. Approximately 78% of all CO emitted in the Study Area is attributed to road vehicles.

Percentage contribution of emissions by county is given in Figure 10. Most particulates are emitted in Lucas and Monroe Counties, each contributing 48% of the total load. Lucas has the majority of SO_X emissions with 61%, followed by Monroe with 37%. Since most of the traffic is centered in Toledo, Lucas County emits the greatest share of CO pollution--69% of all CO in the Study Area.

Grid coordinates based on the Universal Transverse Mercator System were used in the inventory to aid in determining the location of sources and emissions. As shown in Figure 11, the Study Area was divided into 49 grids of three different sizes--25, 100, and 400 square kilometers. The estimated annual emissions of each of the three contaminants by grid zone were converted to daily emissions for average, maximum, and minimum space-heating days. Average emission densities were determined by relating the total quantity of pollutants emitted in each of the grid zones to the land area of each zone. The estimated emission densities by grid zone for average space-heating days are shown in Figures 12, 13, and 14. Figure 12 shows that high sulfur oxides emission





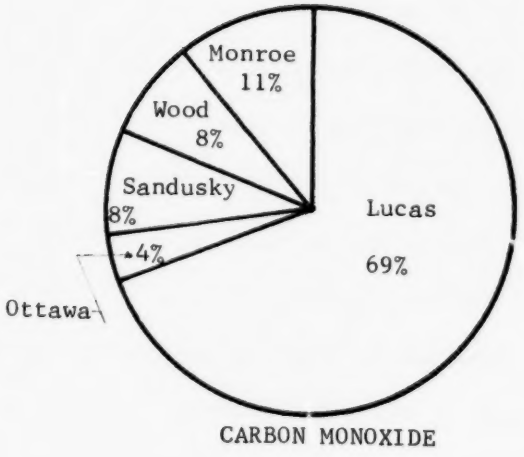


Figure 10. Percent Contribution to Emissions of Particulates, SO_X, and CO by the five Counties in the Toledo Study Area.

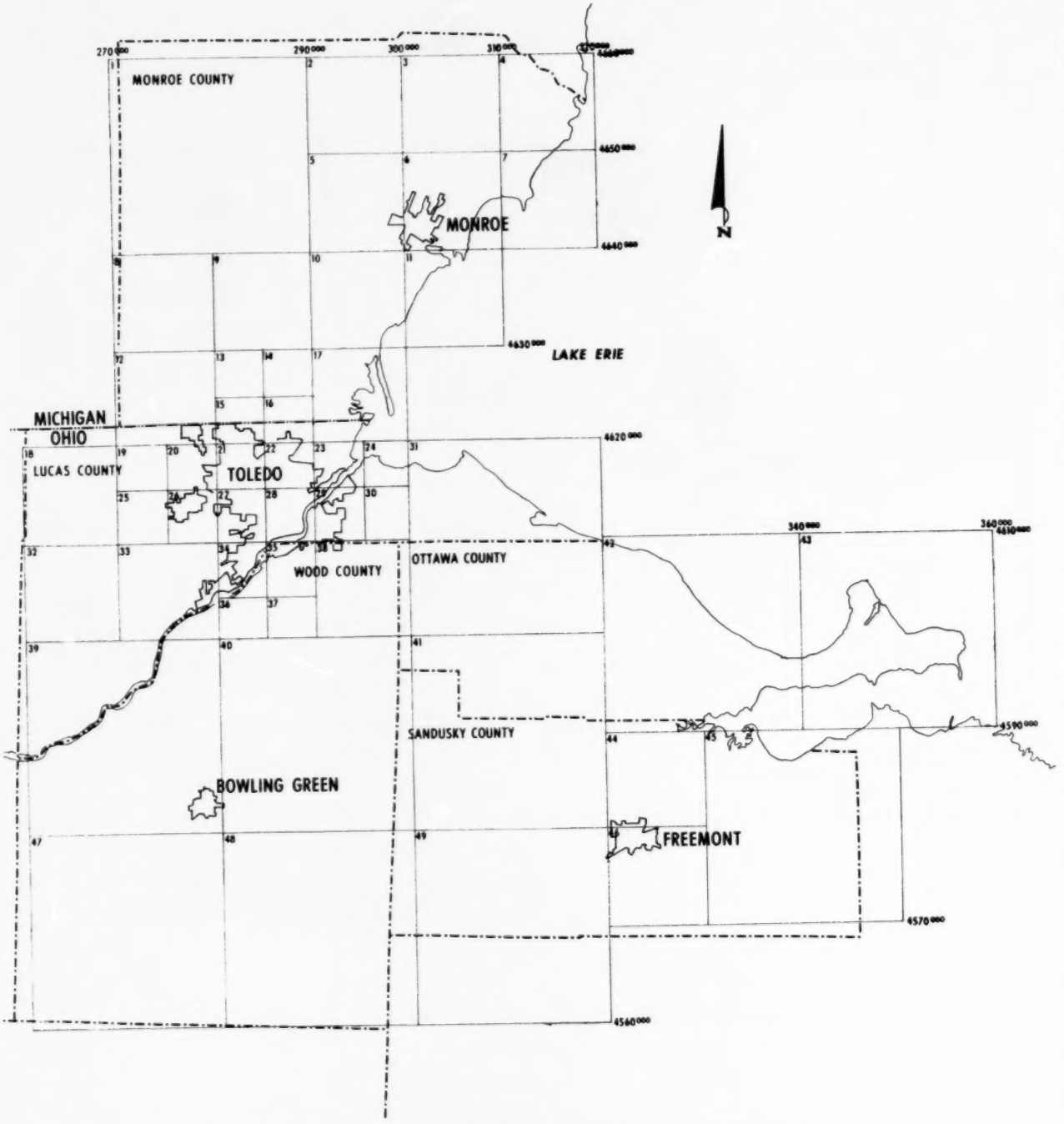


Figure 11. Grid coordinate system for the Toledo study area.

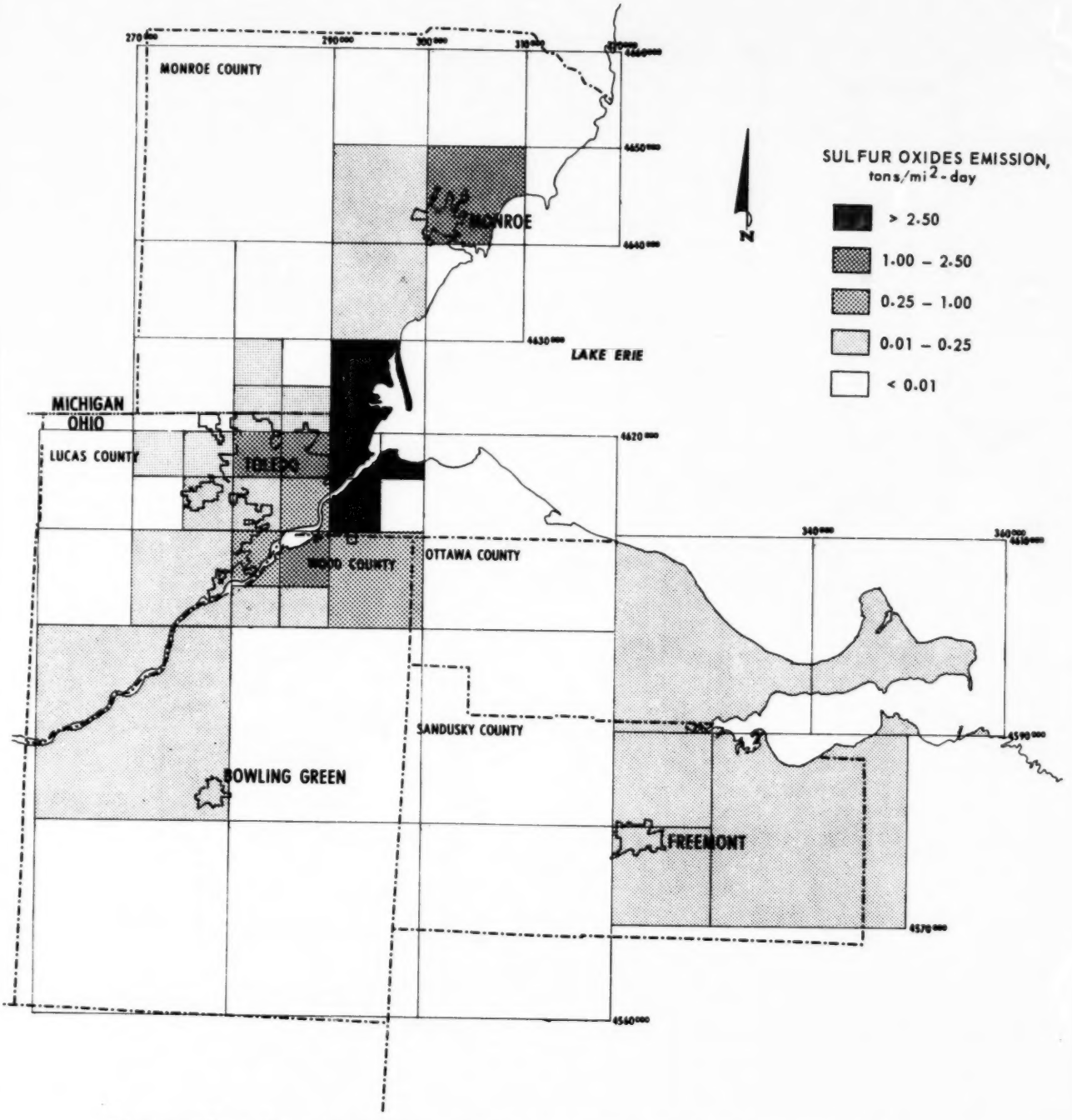


Figure 12. Sulfur oxide emission density from all sources for Toledo study area.

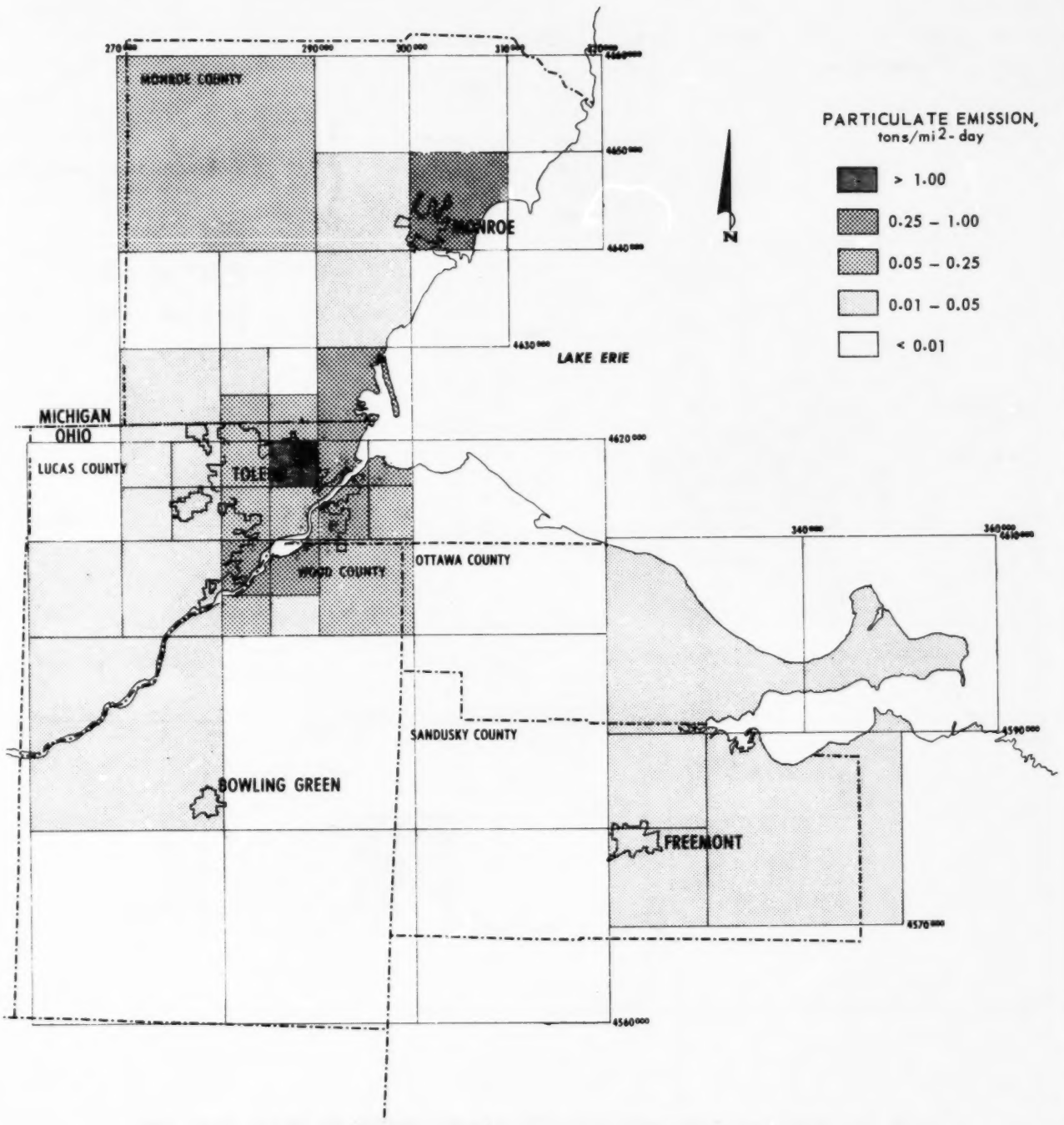


Figure 13. Particulate emission density from all sources for Toledo study area.

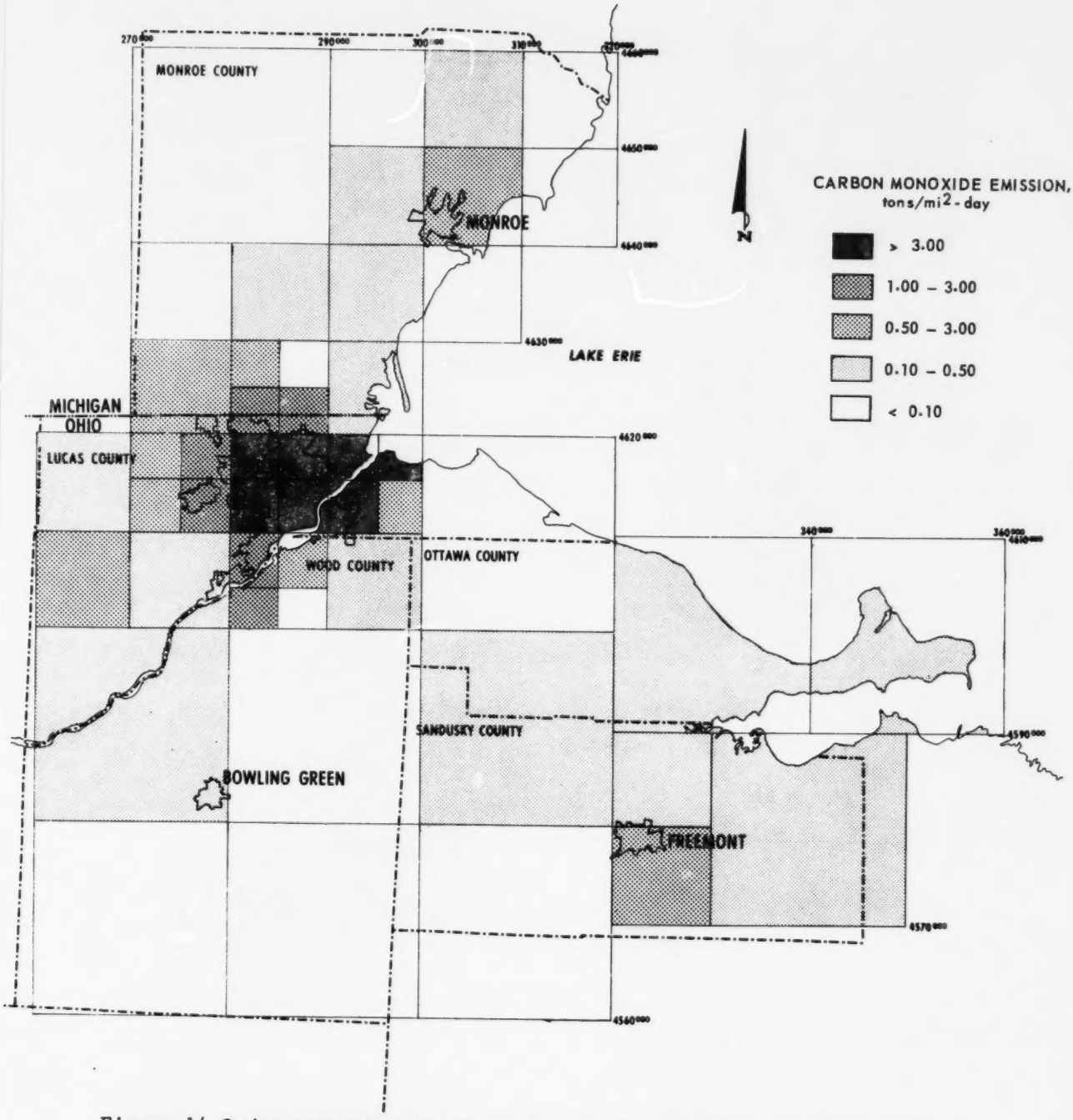


Figure 14. Carbon monoxide emission density from all sources for Toledo study area.

densities closely correlate with the location of power plants. Particulate emission densities are highest where there are clusters of industrial point sources. Carbon monoxide emission densities are closely related to the pattern of urbanization since the automobile is the main contributor of carbon monoxide pollution. Figure 15 shows the location of major point sources in the Study Area.

ANALYSIS OF AIR QUALITY

A study of air quality levels, measured and estimated, is useful in determining those areas which are significantly affected by pollution sources. Such analysis can be based directly on air quality sampling data in those instances where the sampling program for particulates, carbon monoxide, and sulfur oxides covers a sufficiently large area. Air quality data, measured over a time period long enough to provide a reliable spatial pattern, rarely exixts. It becomes necessary in this situation to estimate prevailing air quality through use of a diffusion model.

The Martin-Tikvart model[5] used in this study represents a mathematical approach by which the spatial distribution of pollutant concentrations in the ambient air may be predicted. Input parameters such as average wind speed and direction (Figure 8), mixing depths (Figure 8), and estimated pollutant emissions are utilized in the model to calculate theoretical long-term air quality conditions. The wind data and mixing depths used in the model were considered representative of the conditions throughout the Study Area.

The diffusion model analysis of the Study Area included input from the five counties only. Thus, the effect of the metropolitan

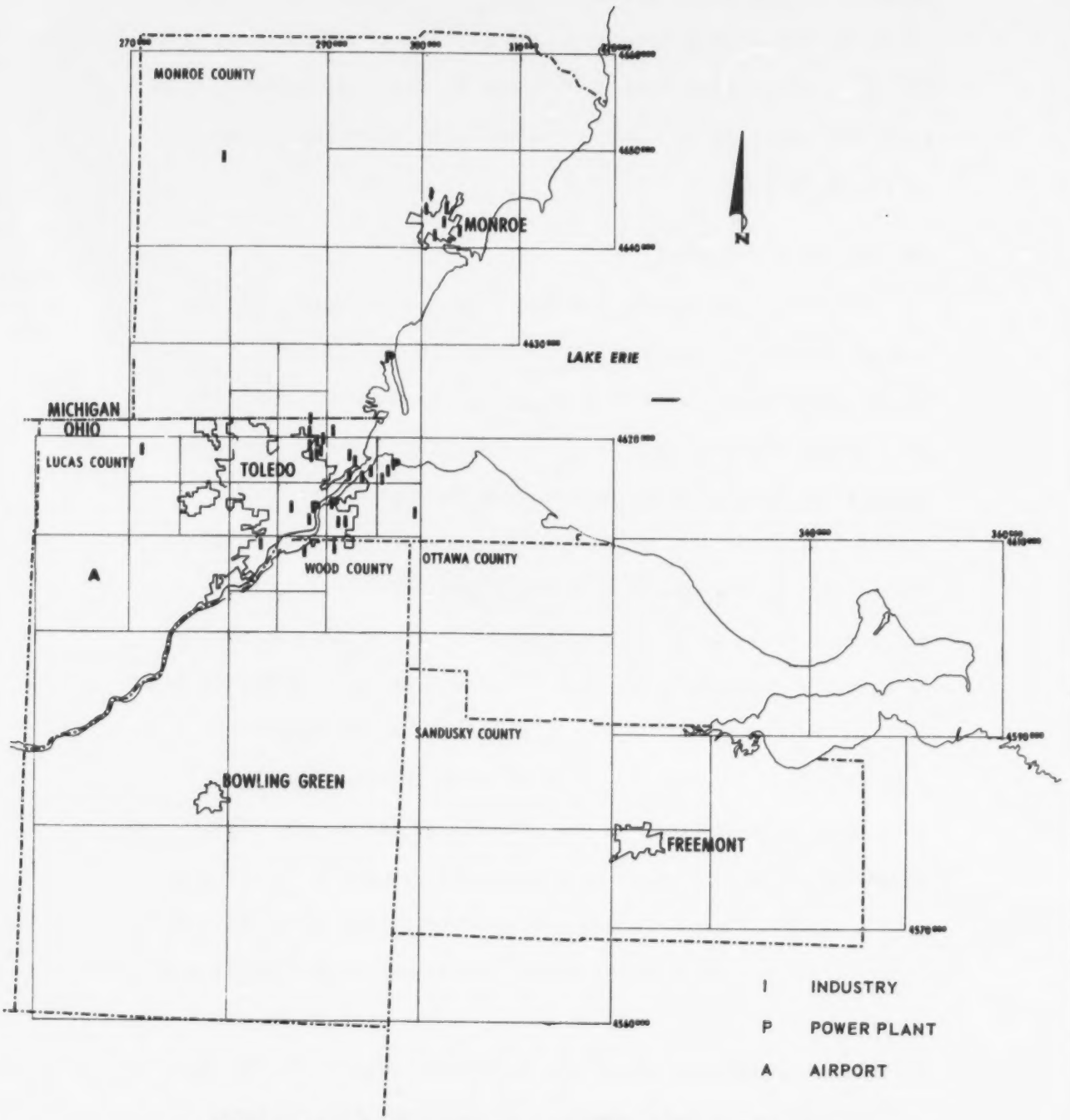


Figure 15. Point source location map for Toledo study area.

Detroit area is not shown in the model output. A model analysis of the Detroit area, which considered emission estimates from Macomb, Oakland, St. Clair, and Wayne Counties, and average wind data from the Detroit City Airport, was available from a previous report recommending an air quality control region in the Detroit area. The model isopleths from Detroit were combined with those from the Toledo Study Area to show the combined effect of the pollution emanating from the Port Huron-Detroit-Monroe City-Toledo corridor. Accordingly, two theoretical pollution contour maps are shown for each pollutant in the next sections. The first shows the theoretical spatial distribution of pollutants from sources in the 5-county Toledo Study Area only. The second presents the theoretical spatial distribution as predicted by combining the contours from the Toledo Study Area and the 4-county Detroit area.

By estimating the patterns of dispersion of three major pollutants--particulates, carbon monoxide, and sulfur oxides--the diffusion model technique provides a guide to the Region boundaries but does not dictate the exact boundary location.

Suspended Particulates

The City of Toledo Pollution Control Agency has an extensive hi-vol sampling network which covers urban Toledo. Samplers are also located in Oregon and Rossford. The average for 12 stations in the area since April, 1967, is 98 $\mu g/m^3$. The National Air Surveillance Network sampler located in downtown Toledo showed an average of 91 $\mu g/m^3$ for 1968. Figure 16 shows suspended particulate

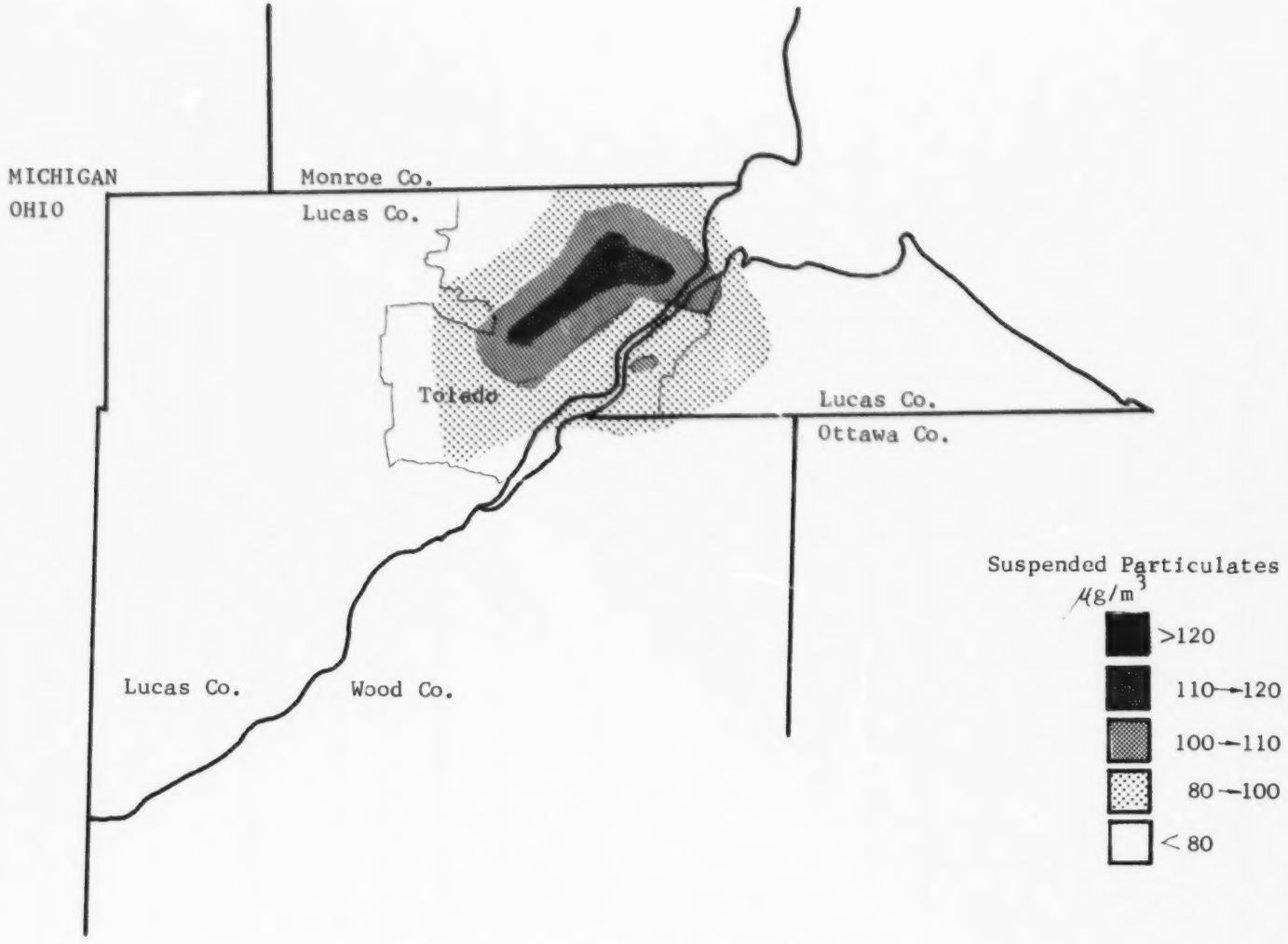


Figure 16. Measured Suspended Particulate Levels--April, 1967, to Present.

levels based on the available measured air quality data. Though no samples are available from southeastern Monroe County, it appears, by extrapolation, that the pattern of suspended particulate pollution from Lucas County extends into Monroe County, and that concentrations of about 80 $\mu g/m^3$ exist in that area on an annual basis. Parts of Lucas County outside of Toledo and Wood County also show suspended particulate levels of above 80 $\mu g/m^3$.

Figure 17 shows the concentration contours produced by the diffusion model using emission estimates from Monroe, Lucas, Wood, Ottawa, and Sandusky Counties only. The contaminant levels tend to be lower than the levels shown in Figure 16.* The general pattern of pollution dispersion, however, is perhaps more important than the estimated concentrations. The contours are elongated in the direction of a line from Toledo to Monroe City with two nodes of high concentrations in the vicinity of these cities. This shape is a result not only of the influence of high emission rates from these cities, but also of the predominance of winds from the WSW-SSW direction in and around Toledo.

The diffusion model results from the Toledo Study Area were combined with those from the Detroit area to form the theoretical contours of Figure 18. Figure 18 shows perhaps a more realistic picture of the spatial distribution of suspended particulate

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* Besides the general limitations of the diffusion model (general long-term meteorological data, estimated emissions, etc.) the model input does not include background levels of suspended particulates (approximately 40 $\mu g/m^3$). If this value were added to the initial output values, the adjusted values would compare more favorably with measured data.

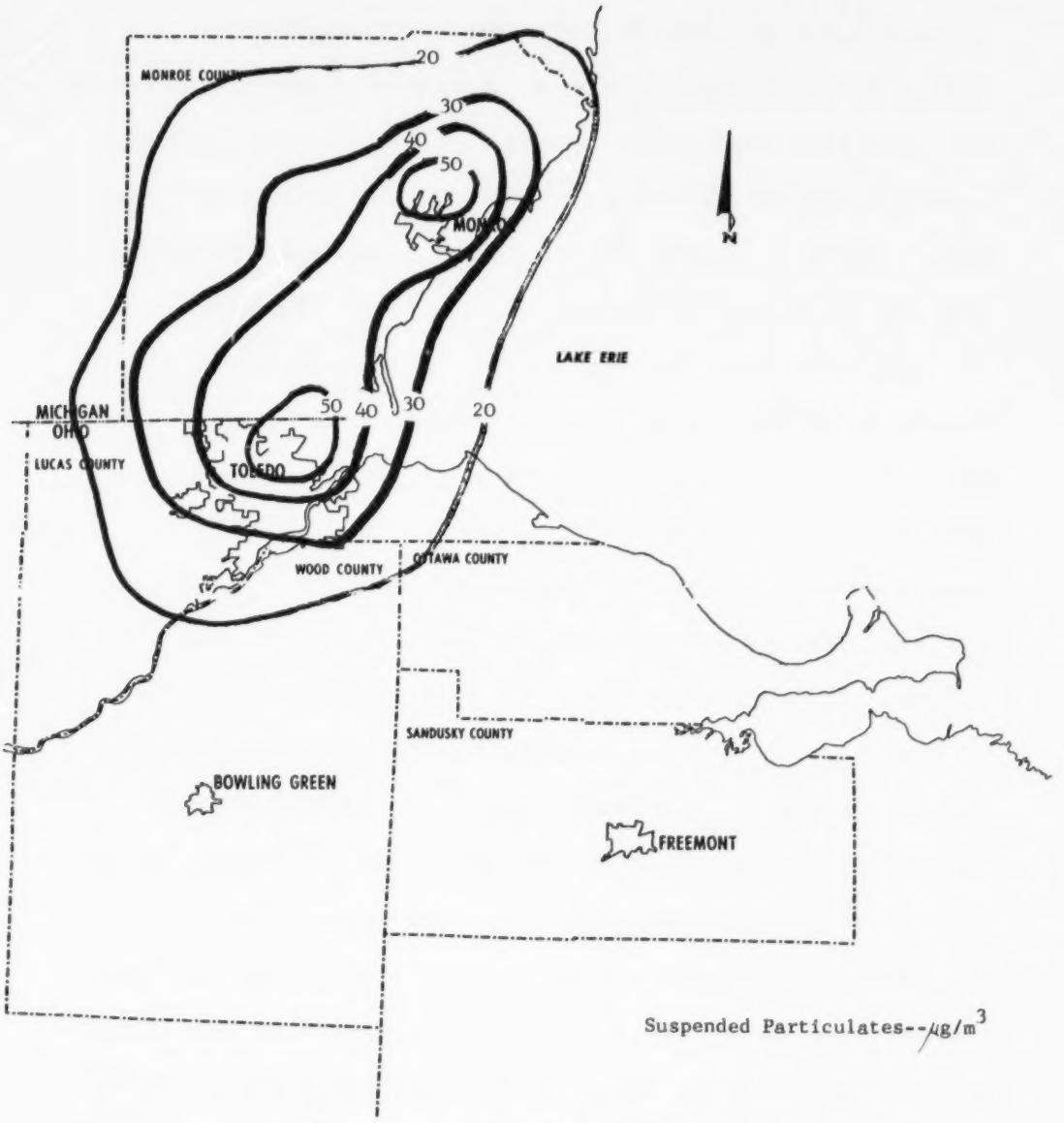

Figure 17. Theoretical Suspended Particulate Levels Based on Emissions from the 5-County Toledo Study Area (does not include background). Annual Average.

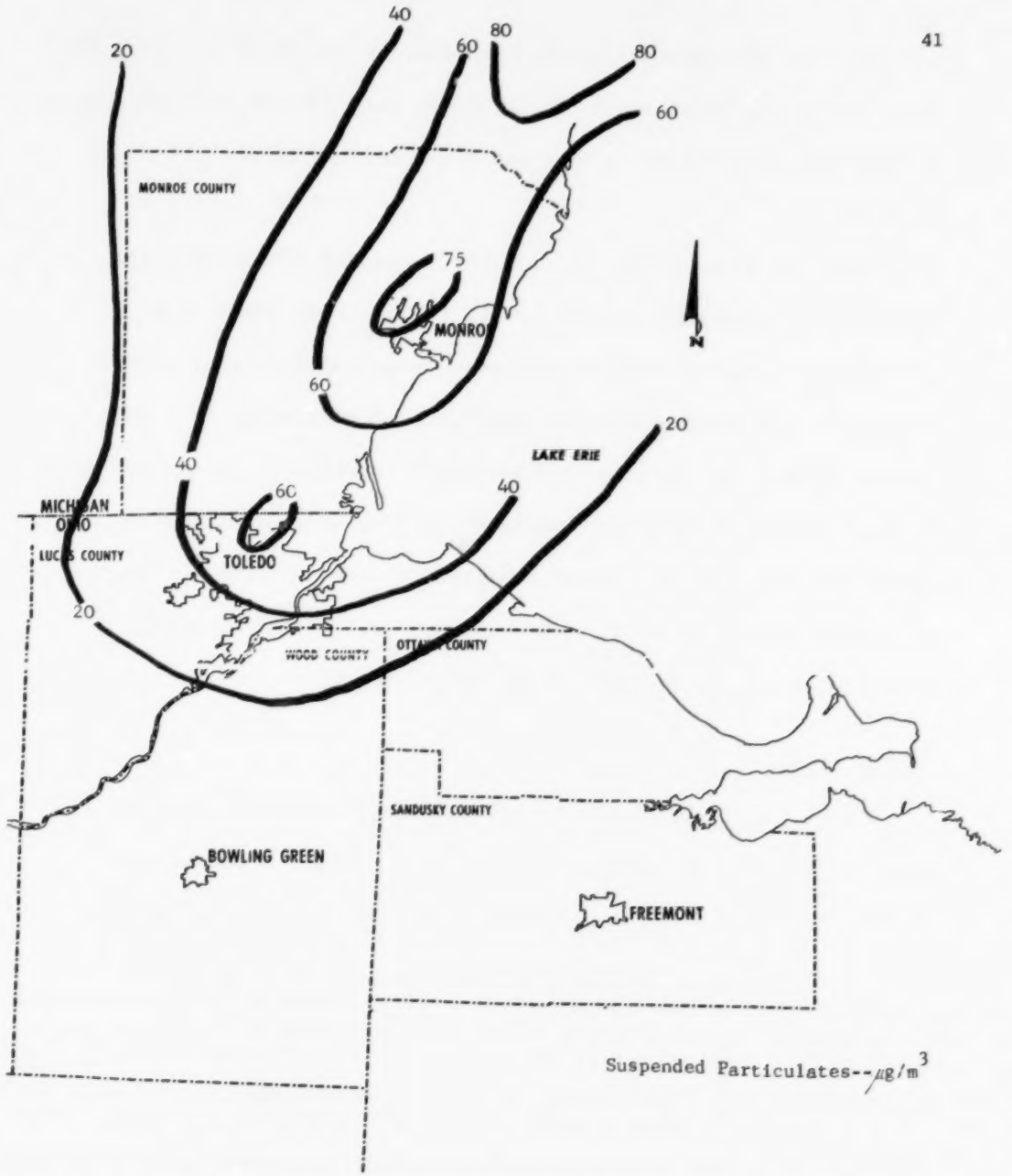

Figure 18. Theoretical Suspended Particulate Levels based on a Combination of the Sets of Isopleths from the Detroit and Toledo Study Areas. Annual Average. (Does not include Background).

pollution in the Detroit-Toledo corridor. The pattern of suspended particulate pollution tends to follow an axis running through Detroit, Monroe City, and Toledo, where the major sources of pollution are located.

Based on Figures 16, 17, and 18, Lucas and Monroe have the highest suspended particulate levels in the Study Area. The north-east corner of Wood County shows measured levels of around 80 $\mu g/m^3$. The diffusion model results confirm that part of Wood County is part of the area-wide pollution problem. No measured data is available from Ottawa and Sandusky Counties. The diffusion model results show that a small portion of the northwest corner of Ottawa County is affected by suspended particulates emanating from the core area located in and around Toledo.

Sulfur Oxides

Table III shows available measured sulfur dioxide sampling data taken at three locations in the Study Area. A comparison of the data is difficulat since the sampling occurred at various

Table III. Measured Sulfur Dioxide Concentrations

Location of Sampler	Agency	Concentration	Time Period
No. 1 Fire Station Leeds and Northrop Toledo Ground-level	Toledo Pollution Control Agency	0.039 ppm ($\sim$109 $\mu g/m^3$)	Daily average 6 months (April-Sept., 1969)
Health Dept. Bldg. 635 N. Erie Street Toledo 45 feet off ground	National Air Surveillance Network	0.015 ppm ($\sim$40 $\mu g/m^3$)	37 daily samples, Jan., 1968,--June, 1969.
State park near Monroe City Monroe County	Michigan State Air Pollution Control Section	Max. 0.06ppm hourly Max. 0.01 ppm 3-day	1 week in July 1 week in Aug. 1969

times of the year and the duration of the sampling periods are different in each case.

The diffusion model contour lines for SO_X are shown in Figures 19 and 20. Figure 19 shows the isopleths produced by using input parameters from the 5-county Toledo Study Area only. Comparison of the 0.05 ppm contour in Toledo with the SO_2 sampling data in Table III shows that the diffusion model overestimated the SO_X levels. As with suspended particulates, the general pattern of pollution dispersion extends north-northeastward from Toledo.

Figure 20 represents a summation of the diffusion model output from the Toledo and Detroit Study areas. The pattern resembles that of the theoretical suspended particulate isopleths.

Based on the diffusion model contours, essentially the same area is affected by region-wide sulfur oxide pollution as is affected by suspended particulate pollution--Lucas and Monroe, and small parts of Wood and Ottawa Counties.

Carbon Monoxide

Figure 21 shows the theoretical CO concentration isopleths produced by the diffusion model. There is no available sampling data. The highest carbon monoxide levels are shown to be in Toledo where traffic volume is greatest.

The combined Detroit-Toledo diffusion model contours are shown in Figure 22. The pattern is very similar to those of suspended particulates and sulfur oxides.

SUMMARY OF ENGINEERING EVALUATION

The rapid survey emissions inventory gave estimates of pollution

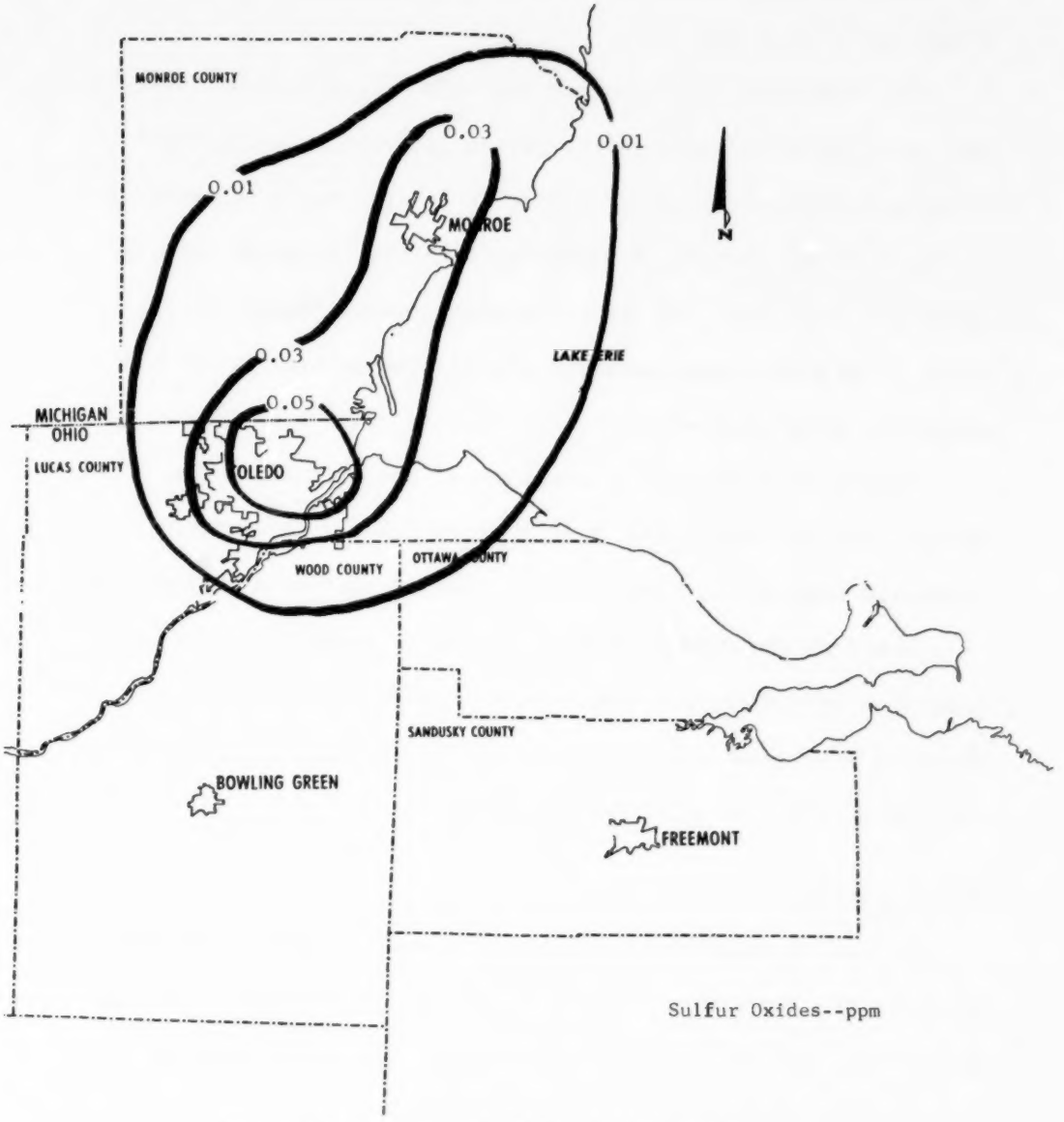

Figure 19. Theoretical Sulfur Oxides Levels Based on Emissions from the 5-County Toledo Study Area. Annual Average.

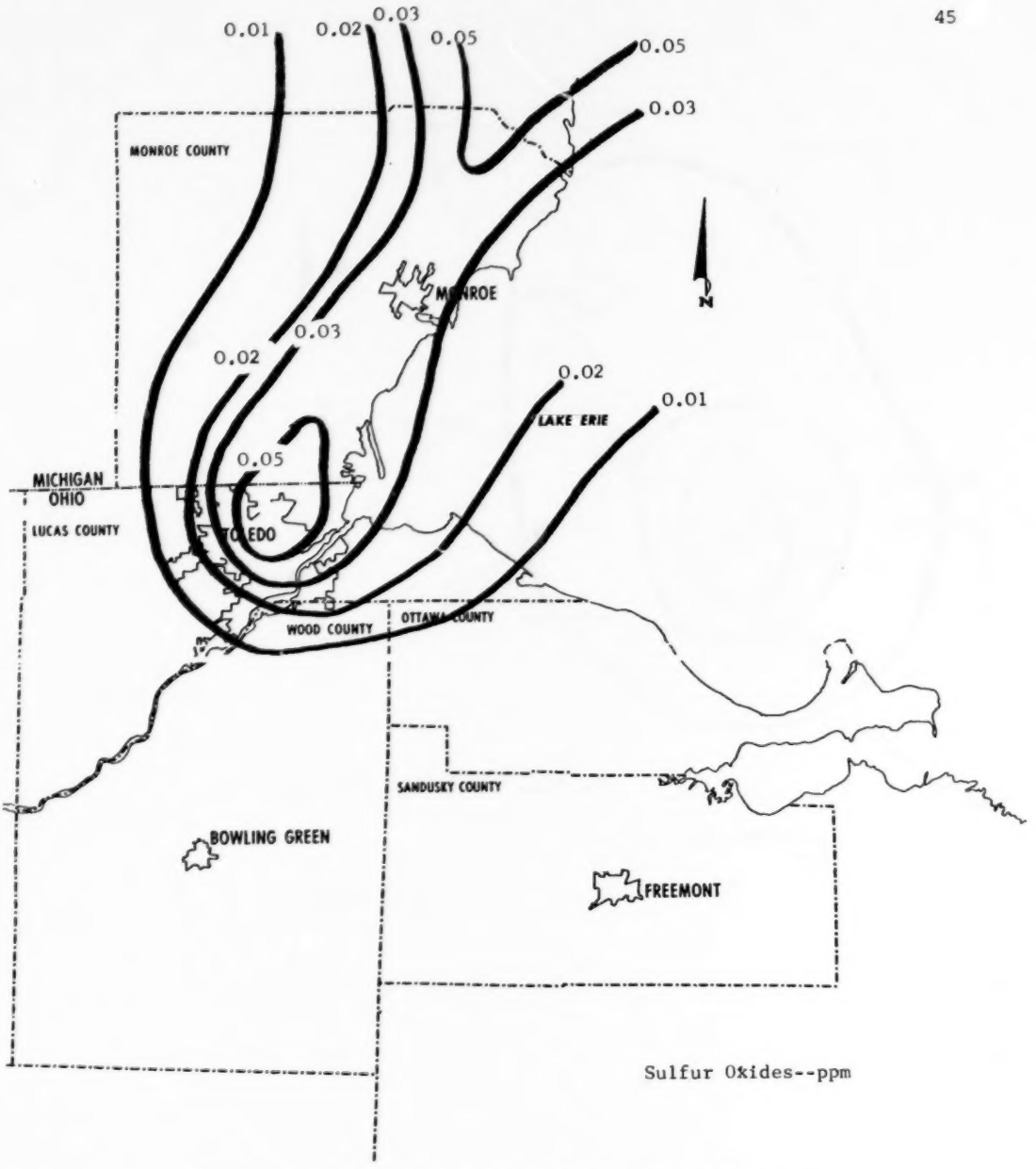

Figure 20. Theoretical Sulfur Oxides Levels based on a Combination of the Sets of Isopleths from the Detroit and Toledo Study Areas. Annual Average.

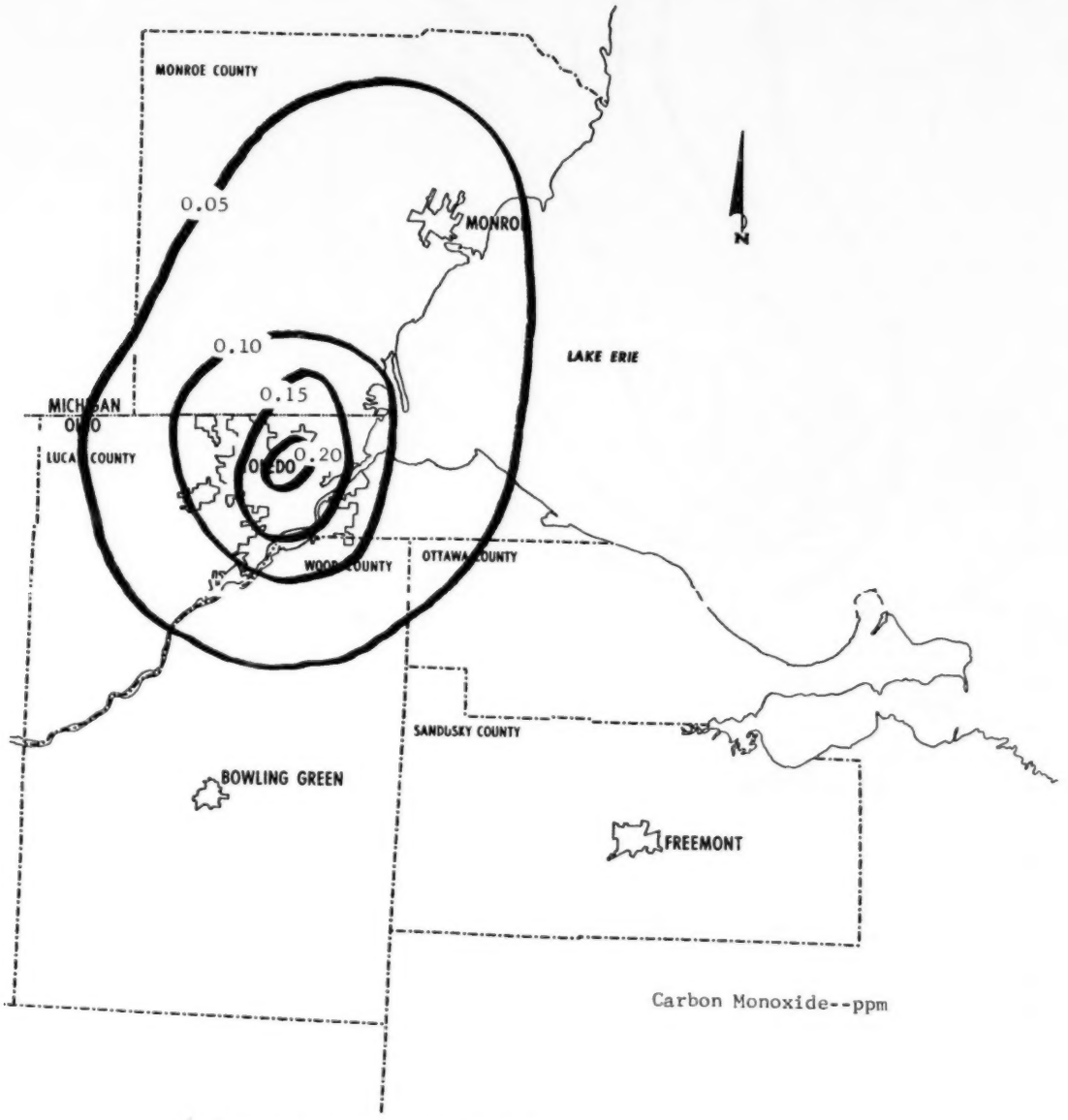

Figure 21. Theoretical Carbon Monoxide Levels based on Emissions from the 5-County Toledo Study Area. Annual Average.

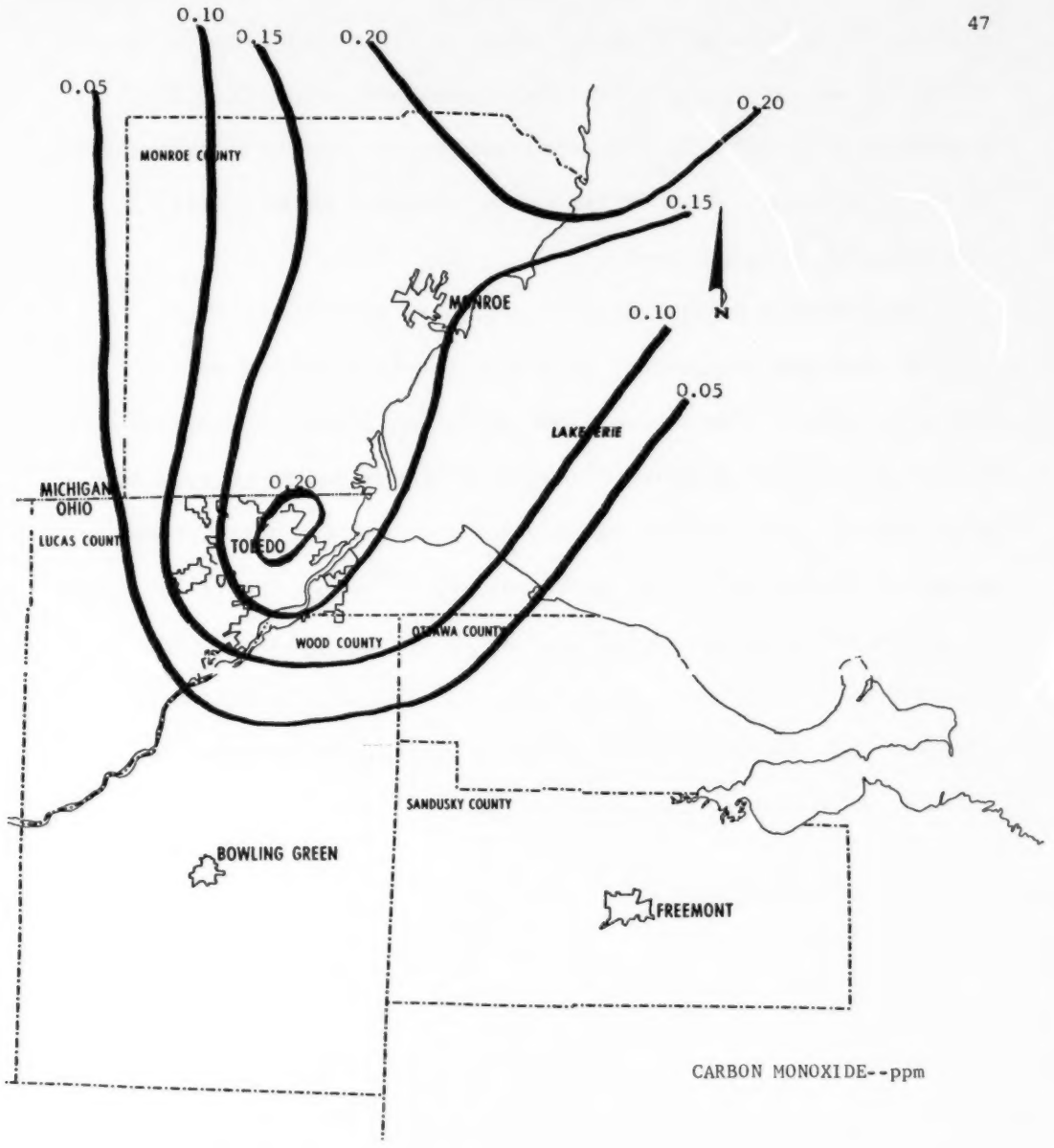

Figure 22. Theoretical Carbon Monoxide Levels based on a Combination of the Sets of Isopleths from the Detroit and Toledo Study Areas. Annual Average.

loadings by county and by source category for particulates, sulfur oxides, and carbon monoxide. Lucas and Monroe Counties contribute over 95% of the particulates and sulfur oxide emissions in the Study Area. Most of the carbon monoxide emissions are concentrated in Lucas County.

The analysis of air quality considered both measured air quality data and theoretical pollutant levels predicted by a diffusion model. The regional air pollution problem as indicated by the patterns of pollution dispersion appear to extend primarily over most of Lucas and Monroe Counties and over the northeastern corner of Wood County. The northwest tip of Ottawa County may be considered part of the regional air pollution problem. The prevailing winds in the area are from the southwest which would indicate that Sandusky County is not a significant receptor of Toledo's pollution at the present time.

THE PROPOSED REGION

Subject to the scheduled consultation, the Secretary, Department of Health, Education, and Welfare, proposes to designate an air quality control region for the metropolitan Toledo area, consisting of the following jurisdictions:

In the State of Ohio:	In the State of Michigan:
Lucas County	Monroe County
Wood County	

As so proposed, the Metropolitan Toledo Interstate Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the above jurisdictions and the territorial area of all municipalities located therin and as defined in Section 302(f) of the Clean Air Act, 42 U.S.C. 1857h(f). Figure 23 shows the boundaries of the proposed Region while Figure 24 indicates the geographic relationship of the Region to the surrounding area.

DISCUSSION OF PROPOSAL

To be successful, an air quality control region should meet three basic conditions. First, its boundaries should encompass most of the pollution sources as well as most of the people and property affected by those sources. Second, the boundaries should encompass those locations where industrial and residential development will create significant air pollution problems in the future. Third, the boundaries should be chosen in a way which is

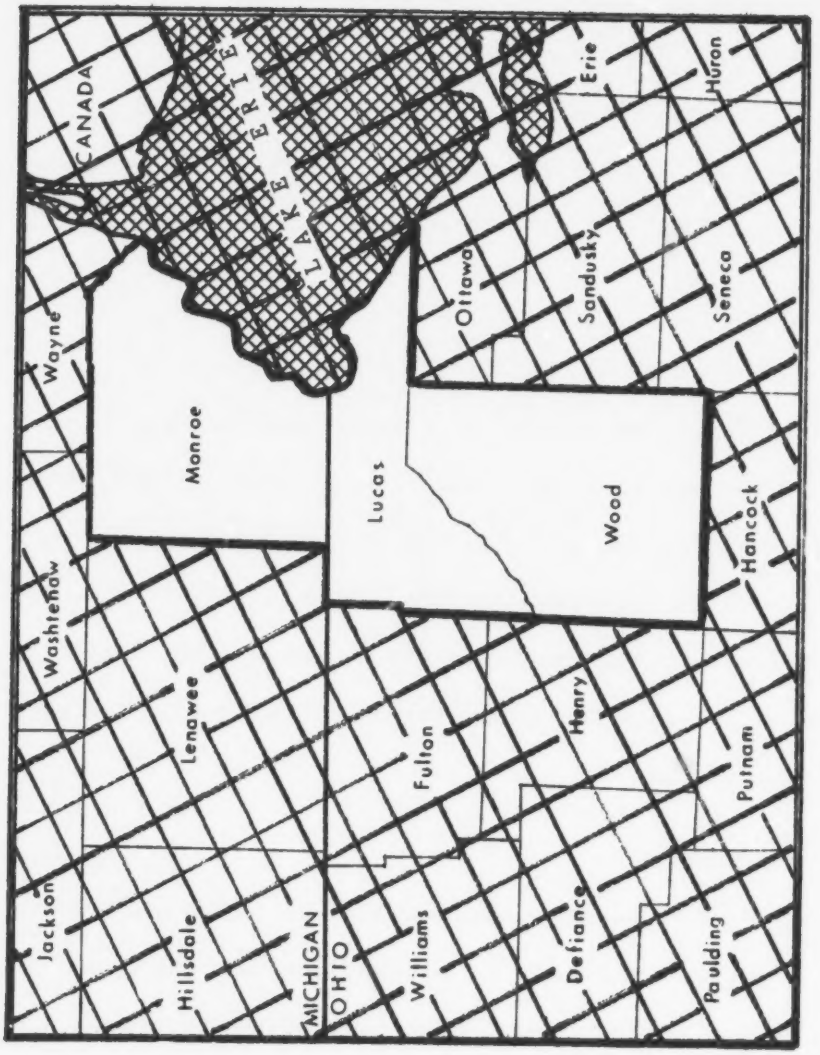

Figure 23 . Proposed Metropolitan Toledo Interstate Air Quality Control Region.

Figure 24. Relationship of Proposed Metropolitan Toledo Interstate Air Quality Control Region to surrounding areas.

compatible with and even fosters unified and cooperative governmental administration of the air resource throughout the region. The "Evaluation of Engineering Factors" (discussion beginning with page 24) discussed the first of these conditions, and the "Evaluation of Urban Factors" (page 11), the second and third. The determination of regional boundaries requires that both urban and engineering factors be considered. The boundaries chosen should create a cohesive combination of jurisdictions suitable for region-wide administration of an air resource management program.

The rapid-survey emissions inventory gave estimates of emission densities and location of major point sources in the five-county Study Area. Highest emission densities of sulfur oxides and particulates are found in and around Toledo. A second center is located in Monroe City. Carbon monoxide emissions are more widely distributed throughout the Study Area, with the highest densities in Toledo where the traffic density is greatest. Otherwise, high emission densities of CO tend to follow major traffic arteries.

The analysis of air quality, based on both measured and predicted levels, indicates that portions of Lucas, Monroe, and Wood Counties are affected by pollution emanating from the Toledo core area. The northwest tip of Ottawa County may also be affected to some degree.

Proposing the inclusion of Monroe County in an air quality control region with Toledo instead of with Detroit is based partly

on the fact that Toledo abuts the southern boundary of Monroe County and the suburban areas of Toledo extend into the County. Major population growth is predicted to occur to the north and south of Toledo. This pressure will be felt by southern Monroe County in years to come. Perhaps more important, however, is the pollution dispersion pattern which would indicate a strong tie between Lucas and Monroe County. Predominant winds in the Toledo area are from the WSW-SSW, and such winds would often make southeast Monroe County a receptor of pollution from Toledo. The combination of diffusion model contours from Detroit and Toledo show a corridor of pollution running from Toledo to Detroit, covering the eastern half of Monroe County. A true assessment of the relative impacts of Detroit's and Toledo's pollution emissions on Monroe County is difficult due to the lack of measured air quality data in Monroe County. However, Toledo's proximity to Monroe County coupled with the meteorological factors presents a case for an air quality control region with Lucas and Monroe County together.

The population of the 3-county proposed Region represents about 88% of the population in the 5-county Toledo Study Area. The Ohio portion of the proposed Region contains 572,000 people, or about 5% of the population of the State of Ohio. Thus, along with the Cleveland, Dayton, Cincinnati, and Steubenville Air Quality Control Regions, over 64% of the population of Ohio will be part of Federally designated air quality control regions. Monroe County represents 1.3% of the population of the State of Michigan. Along

with the Detroit Region (4 counties), over 50% of the population of the State of Michigan will be covered by air quality control regions.

The proposed Region allows for both population and industrial growth in the future. Growth from Toledo is projected to occur to the north and south of the city. Ottawa and Sandusky Counties, however, show considerable population growth potential, and serious consideration should be given to their inclusion in the Region.

The third objective, that existing jurisdictions be considered, is the most difficult to meet. The Toledo area presents a unique situation in that Monroe County lies between two large and growing metropolitan areas. The County government is a member of both SEMCOG and TMACOG, and the three southern townships are represented on TMACOG. Though the National Air Pollution Control Administration attempts, when feasible, to propose Regions which are compatible with existing regional government and planning arrangements, air pollution and its dispersion must remain the most important consideration when designating an air quality control region. And, unless overriding considerations dictate the splitting of a county, NAPCA tries to preserve the county as the basic jurisdiction within the Region. Inclusion of Monroe County in the Toledo Air Quality Control Region will help insure that the air quality standards set after designation are compatable within the Toledo-southern Monroe County air shed. An interstate region, especially one where local governments have dual-membership in regional agencies, requires a high degree of cooperation and coordination among the two states and local governments involved. Where

possible, the States of Michigan and Ohio should explore the extent to which they can rely on the existing regional arrangements as mechanisms of coordination.

Ottawa and Sandusky Counties are not recommended for inclusion in the Region at this time since they do not appear to be a part of the regional air pollution problem and are not part of the regional planning agencies and councils of government. However, population projections show that potential for growth exists in both counties. Thus, even though they have not been included in the proposed boundaries for the Region, the final decision on the inclusion or exclusion of Ottawa and Sandusky Counties will be made only after careful review of comments submitted to the Consultation record by State and local officials.

The boundaries proposed in this report for the Metropolitan Toledo Interstate Air Quality Control Region will serve as a starting point for discussion with State and local officials at the scheduled Consultation.

APPENDIX A

Section 107(a)(2), Clean Air Act, as amended:

"For the purpose of establishing ambient air quality standards pursuant to section 108, and for administrative and other purposes, the Secretary, after consultation with appropriate State and local authorities shall, to the extent feasible, within 18 months after the date of enactment of the Air Quality Act of 1967 designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards. The Secretary may from time to time thereafter, as he determines necessary to protect the public health and welfare and after consultation with appropriate State and local authorities, revise the designation of such regions and designate additional air quality control regions. The Secretary shall immediately notify the Governor or Governors of the affected State or States of such designation."

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